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JOSEPH A. CUSHMAN, Editor

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JOURNAL OF PALEONTOLOGY

MARCH 1928

LOWER MIOCENE FOSSILS FROM PORTUGUESE EAST AFRICA

HELEN K. HODSON
Maracaibo, Venezuela

ABSTRACT

These Lower Miocene collections contain a number of species of foraminifera related to those of similar age from the islands of the Indo-Pacific. This general horizon is characterized by *Amphilepidina*, *Miogypsina* and *Cycloclypeus* and seems not to have been previously recorded from Portuguese East Africa. Two species are new, one an *Operculinella*, the other a *Lepidocyclina*.

INTRODUCTION

The two collections upon which the following observations are based were made by Mr. L. S. Thompson in Portuguese East Africa. The one from the Catholic Mission opposite Morrumbene, Circumscription of Inhambane, District of Inhambane, is a yellow, sandy, somewhat argillaceous, foraminiferal limestone, which grades into a foraminiferal sandstone. The fossils are not particularly well preserved because the calcite is recrystallized. Its fauna includes: *Lepidocyclina* (*Amphilepidina*) *inhambanensis* (n. sp.), *L.* (*A.*) sp. (stellate externally, new and scarce), *L.* sp. (microspheric), *Cycloclypeus* sp. (fragments), *Operculina complanta* (Defrance), *Operculinella inhambanensis* (n. sp.), *Lenticulina* sp., *Rotalia beccarii* (Linné), *Globigerina bulloides* d'Orbigny, *Cibicides lobatula* (Walker and Jacob), *Gypsina globula* (Reuss), *G. vesicularis* (Parker and Jones), *Nodosaria* sp., *Nonion scapha* (Fichtel and Moll), *Elphidium* sp. The other collection, from Rovene, Circumscription of Massinga, District of Inhambane, is a hard, yellow, somewhat sandy, somewhat

argillaceous, foraminiferal, algal limestone. The fossils are not particularly well preserved because the calcite is recrystallized and the rock is hard. The fauna includes: *Lepidocyclina* (*Amphilepidina*) *inhambanensis* (n. sp.), *L.* (*A.*) sp. (somewhat stellate exteriorly), *Miogypsina thecideaeformis* (Rutten), *Cycloclypeus* sp., *Operculina complanta* (Defrance), *Nonion scapha* (Fichtel and Moll), *Quinqueloculina* sp.

The beds represented are evidently of Aquitanian or Burdigalian age and belong to the same widely spread, Lower Miocene series that outcrops on many of the islands in the Indo-Pacific region. This general horizon is characterized by *Amphilepidina, Miogypsina,* and *Cycloclypeus,* and seems not to have been previously recorded from Portuguese East Africa. The literature on it is scattered through numerous publications, but most helpful are the articles in the "Sammlungen des geologischen Reichs-Museums in Leiden" and H. Douvillé's "Revision des Lépidocyclines", 1924. In these works, the stratigraphic range for *Miogypsina* and *Amphilepidina* in the Indo-Pacific region is given as through the upper half of the Aquitanian and through the Burdigalian; *Cycloclypeus* is not recorded in the literature as occurring below the upper half of the Aquitanian, and is still living in that region. Upon these ranges is based the Lower Miocene age of these collections.

Grateful acknowledgement is made to Dr. Floyd Hodson for his help and interest in working up these collections.

The specimens figured are deposited in the collections of Prof. G. D. Harris in the Paleontological Museum at Cornell University, Ithaca, New York.

DESCRIPTION OF SPECIES

Family NUMMULITIDAE Reuss, 1862

Genus OPERCULINELLA Yabe, 1918

OPERCULINELLA INHAMBANENSIS, n. sp.

Plate 1, figs. 1, 3, 4

The megaspheric test is involute, small, and lenticular, lacks a thin encircling collar, and measures about 1.4 mm. in width and 0.35 mm. in thickness. The surface is smooth and shows narrow radial lines representing the septae; these lines are about 64μ apart and extend from the center toward the periphery; they are directed sharply forward and are sometimes meandrous. On specimens whose external layer is weathered away, these radial lines stand out as ridges.

In equatorial section, a test 1.5 mm. in diameter consists of about 5 coils; the chambers increase rapidly in size from very small to larger, oblique, narrow chambers which occupy a space of 130μ between the whorl laminae; the round embryon measures about 53μ in diameter; the outer edge of the coils increases in width peripherally, measuring about 86μ in the fourth whorl; the septae of the chambers are very oblique, curved, and average 22μ in thickness in the fourth whorl.

This new species is remarkable for its small size, its oblique septae, its narrow chambers, and its lack of a thin encircling collar.

Age: Aquitanian or Burdigalian.

Locality: Catholic Mission opposite Morrumbene, Circumscription of Inhambane, District of Inhambane, Portuguese East Africa.

Family ORBITOIDIDAE Cushman, 1927

Genus LEPIDOCYCLINA Gümbel, 1868

Subgenus AMPHILEPIDINA H. Douvillé, 1922

LEPIDOCYCLINA (AMPHILEPIDINA) INHAMBANENSIS, n. sp.

Plate 1, figs. 2, 5, 6; plate 2, figs. 1-3; plate 3, fig. 1

The megaspheric test is lenticular, small, attaining 4 mm. (usually 3 mm.) in diameter, and 1.7 mm. in thickness. There is considerable variation in thickness, but usually the more adult forms are the thicker while the young are very thin. The surface is covered with an irregular, coarse mesh; a few pustules show at the intersections of the meshes; there is no external indication of rays. A vertical section of a larger test shows rather large lateral chambers, strong pillars increasing in width toward the periphery, and an equatorial layer remaining the same width throughout the test. In young specimens, the pillars are very indistinct. In equatorial section the embryon is reniform; the first roundly elliptical chamber averages 340μ in diameter; the second half-embracing one 500μ. The equatorial chambers are very disturbed in their shape and arrangement; when cut through the center, they are usually spatulate and arranged in concentric rings; however, some are ogival and arranged in intersecting curves; there is no regularity determining which part of the layer will have ogival chambers or which will have spatulate, in the young; in medium-sized adult tests, these chambers assume a more or less stellate arrangement; the largest specimens show, toward the periphery, equatorial chambers attaining 90μ in length and arranged in concentric rings; the stellate arrangement is most conspicuous in medium-sized adult tests.

A common, small, microspheric form in the limestone from the Catholic Mission opposite Morrumbene, probably represents this same species. It measures about 6 mm. in diameter, and is very thin and flat. It has no ornamentation or pillars. The equatorial chambers pass through a stellate stage, but become spatulate and arranged in concentric rings at the periphery, where they measure about 86μ in length. No form similar to this has been described in the literature on the Indo-Pacific region.

This species is typical of the subgenus *Amphilepidina*, with its equatorial chambers arranged more or less stellately. It is the most abundant species in the two collections under consideration, and in the one from the Catholic Mission opposite Morrumbene, practically makes up the limestone.

The subgenus *Amphilepidina* is common around the Indian Ocean and near Pacific. It represents the last stages of the originally western genus, whose tests here become stellate or ornate before disappearing. In its typically stellate form, this subgenus has been recorded from only the Indo-Pacific region and as limited in range from Middle Aquitanian to the top of the Burdigalian. *L.* (*Amphilepidina*) *sumatrensis* (Brady)[1] and *L.* (*Amphilepidina*) *inornata* Rutten,[2] which resembles this species, slope abruptly from an inflated center to a thin border, instead of gently as in the new species. The first is recorded from the Burdigalian of the Isle of Nias, from Middle Aquitanian through Burdigalian in Sumatra, and in the Up-

[1] Geol. Mag., vol. 2, no. 137, 1875, p. 536, pl. 14, fig. 3, a, b, c.
[2] Samml. geol. R.-Museums in Leiden, ser. 1, vol. 9, 1913, pp. 294-295, pl. 22, figs. 6-8.

EXPLANATION OF PLATES

PLATE 1

FIG. 1.—*Operculinella inhambanensis*, n. sp. Holotype. Greatest diameter 1.27 mm.

2.—*Lepidocyclina (Amphilepidina) inhambanensis*, n. sp. Microspheric form from the Cathloic Mission opposite Morrumbene. Paratype. Greatest diameter 6.6 mm.

3.—*Operculinella inhambanensis*, n. sp. Paratype, equatorial section. Greatest diameter 1.23 mm.

4.—*Operculinella inhambanensis*, n. sp. Paratype, vertical section. Length 1.7 mm.

5.—*Lepidocyclina (Amphilepidina) inhambanensis*, n. sp. Paratype. Equatorial section of microspheric form from the Catholic Mission opposite Morrumbene. Greatest diameter 4 mm.

6.—*Lepidocyclina (Amphilepidina) inhambanensis*, n. sp. Same specimen as figure 2. Lateral view, thickness 862μ.

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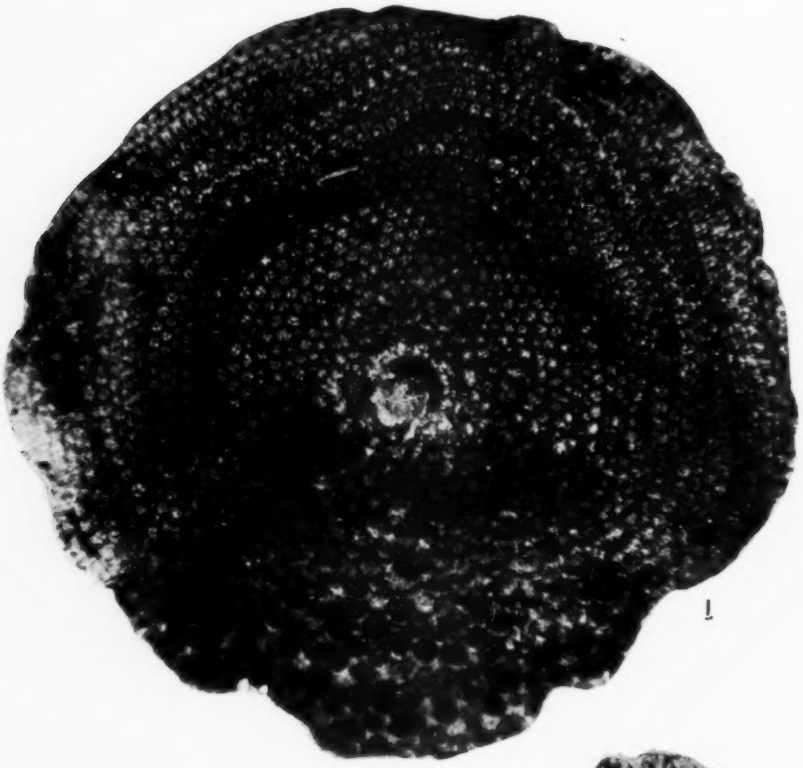
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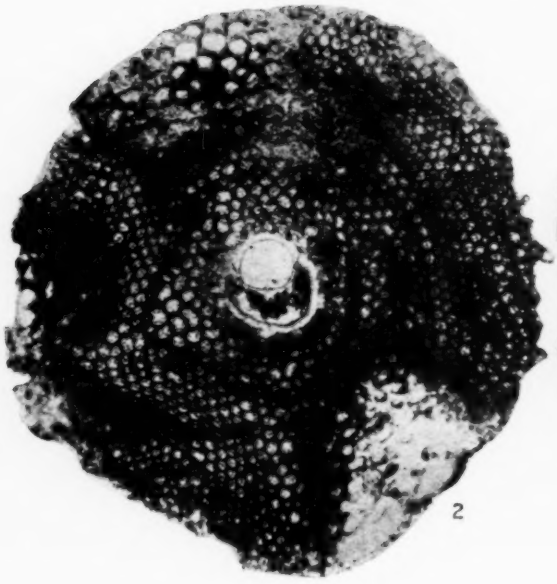
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per Aquitanian in Borneo; the latter is reported from the Upper Aquitanian of Borneo and Tokok (Celebes).

Age: Aquitanian or Burdigalian.

Locality: Catholic Mission opposite Morrumbene, Circumscription of Inhambane, District of Inhambane; and Rovene, Circumscription of Massinga, District of Inhambane, Portuguese East Africa.

Genus MIOGYPSINA Sacco, 1893

MIOGYPSINA THECIDEAEFORMIS (Rutten) Rutten, 1911

Plate 3, figs. 2-6

Lepidosemicyclina thecideaeformis Rutten, Versl. Verg. Kon. Ak. v. Wetensch., Amsterdam, Verg. 25, 2, 1911. (*Fide* Rutten, 1912.)

Miogypsina thecideaeformis (Rutten) Rutten, Sammlungen geol. R.-Mus. in Leiden, series 1, vol. 9, 1912, pp. 204-207, pl. 12, figs. 1-5. *Ibid.*, 1913, p. 287.

This small species of *Miogypsina* is fairly abundant in the limestone from Rovene. Due to the recrystallization of the limestone, the specimens are poorly preserved and frequently broken. They measure only 2 mm. while those from East Borneo, the type locality, are said to measure 3 mm. The arrangement of the chambers is identical. The test is roughly trigonal, convex on one side, and flattened or slightly concave on the other. The surface is covered with minute pustules. The embryonic apparatus is near the periphery, at the apex of the triangle, and consists of a central, round chamber measuring about 150μ, including the chamber wall, with a second semilunar one, about the same size or slightly larger, above and a little to one side. Following the second embryonic chamber are 3-5 more angular chambers, forming a spiral which is soon lost in the mass of diamond-shaped equatorial chambers.

In vertical section, the chambers are very indistinct and their walls are thickened; even the equatorial layer is very poorly demarked in some sections. This may have been true of Rutten's ma-

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EXPLANATION OF PLATES

PLATE 2

FIG. 1.—*Lepidocyclina (Amphilepidina) inhambanensis*, n. sp. Paratype from Rovene. Equatorial section, greatest diameter 3.5 mm.

2.—*Lepidocyclina (Amphilepidina) inhambanensis*, n. sp. Holotype from the Catholic Mission opposite Morrumbene. Equatorial section, greatest diameter 2.8 mm.

3.—*Lepidocyclina (Amphilepidina) inhambanensis*, n. sp. Paratype from Rovene. Vertical section, length 3 mm.

terial from East Borneo, also, for his sketch of the vertical section showing only a few of the chambers would indicate that his vertical sections may have been too poor to be photographed, and his placement of the chambers in the sketch does not look quite normal.

This degeneracy of the lateral chambers is not as conspicuous in America or Europe as in the East. *Miogypsina,* having appeared first in the West in the Upper Eocene, seems to have reached the Indo-Pacific late in its career; it shows there several gerontic and degenerate characteristics. In at least four other of the present thirteen recorded species from the East, the lateral chambers are broken down or consist of calcareous plates and thickenings; these are *M. dehaartii* van der Vlerk,[3] *M. burdigalensis suralilensis* Shubert,[4] *M. tuberosa* Tobler,[5] *M. abunensis* Tobler.[6] In *M. thecideaeformis* (Rutten), the thickening of the walls of the lateral chambers is apparent, but has not yet proceeded far enough to completely obliterate the chambers as in some of the species mentioned above.

The beds in which *M. thecideaeformis* (Rutten) were found were attributed by Rutten in 1913 to the lower half of the Miocene (Aquitanian and Burdigalian), and the genus itself, according to present knowledge is limited to this range in the Indo-Pacific region.

Age: Aquitanian or Burdigalian.

Locality: Rovene, Circumscription of Massinga, District of Inhambane, Portuguese East Africa.

[3] Eclogae Geol. Helvetiae, vol. 18, no. 3, 1924, pp. 429-432.
[4] Abhand. K. K. Geol. Reich., vol. 20, no. 4, 1911, p. 120, pl. 3, fig. 2.
[5] Eclogae Geol. Helvetiae, vol. 20, 1927. pp. 323-327.
[6] Ibid., pp. 327-330.

EXPLANATION OF PLATES

PLATE 3

FIG. 1.—*Lepidocyclina (Amphilepidina) inhambanensis,* n. sp. Paratype from the Catholic Mission opposite Morrumbene. Greatest diameter 3 mm.

2.—*Miogypsina thecideaeformis* (Rutten), from Rovene. Vertical section, length 1.4 mm.

3.—*Miogypsina thecideaeformis* (Rutten), from Rovene. Greatest diameter 1.57 mm.

4.—*Miogypsina thecideaeformis* (Rutten), from Rovene. Fragment of equatorial section showing embryonic apparatus. Greatest diameter 1.18 mm.

5.—*Miogypsina thecideaeformis* (Rutten), from Rovene. Vertical section, length 1.56 mm.

6.—*Miogypsina thecideaeformis* (Rutten), from Rovene. Equatorial section, not quite central, greatest diameter 2.1 mm.

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YABERINELLA JAMAICENSIS, A NEW GENUS AND SPECIES OF ARENACEOUS FORAMINIFERA

By T. WAYLAND VAUGHAN
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ABSTRACT

Yaberinella, of which the genoholotype is *Y. jamaicensis* Vaughan, is a genus of large arenaceous foraminifera of which the growth form in the megalospheric generation is operculinoid and in the microspheric generation it is initially operculinoid but becomes cyclical in a later stage. The internal structure is of a complicated criss-cross pattern. The most nearly related previously described genus appears to be *Dictyopsella* Munier-Chalmas. The specimens described were obtained by Dr. C. A. Matley in the Middle Eocene "Yellow limestone" of Jamaica.

(Plates 4, 5)

The following statement regarding this species was published by me in the paper cited below:

"Dr. C. A. Matley collected in the middle or lower Eocene of Jamaica great numbers of specimens of a genus of foraminifera with which I was hitherto entirely unfamiliar. The microspheric form produces thin flat disks which are as much as 50 millimeters in diameter. The growth form in the early stages is an involute, flat spiral which passes into a concentric growth form, the outer surface of the test being marked by raised [impressed] concentric lines. The interior of the test exhibits a crisscross or zigzag structure between the concentric lines. The macrospheric form resembles in its external features an *Operculina*, and until sections were made I mistook the specimens for *Operculina*. Between what at first appeared to be the chamber walls there is the crisscross structure also seen in the microspheric specimens of concentric growth form. The embryonic chamber is a single, large, undivided chamber, which is succeeded by the operculinoid growth form above indicated. In vertical sections of the macrospheric form there are at least three layers of chambers, a median, with a lateral on each side. I have hastily compared the thin-sections with thin-sections of *Orbitolites complanatus*, *Sorites duplex?*, and *Orbiculina adunca*. Although I have not com-

pleted the study of the specimens, they seem to me to belong to a genus akin to *Orbitolites* and they possibly represent a section of that genus in which the structure is very complex."

More detailed study of the specimens has shown that they represent a genus of arenaceous foraminifera related to *Cyclammina, Choffatella, Pseudocyclammina,* and *Dictyopsella.* Six specimens, all figured, representing the megalospheric form from a single locality, J. 505 M., Phantillands Parochial road, 1.8 mi. from the main road, have been selected as cotypes, and are described below.

YABERINELLA JAMAICENSIS Vaughan, gen. et sp. nov.

Plate 4, figs. 1-7; plate 5, figs. 1-5

1924. *Orbitolites?,* VAUGHAN, Geol. Soc. Amer. Bull., vol. 35, p. 804.

The specimens in general external appearance resemble *Archaias* (=*"Orbiculina"*) *aduncus* (Fichtel and Moll) or *Operculina.* Except that in most specimens the part adjacent to the initial chambers is thickened, the tests are flat involute coils, a thin coating extending from the anterior edge of the growing margin to the initial part of the test and covering it. The size of the test varies according to age. The diameters of the four specimens (antero-postero given first) represented by plate 4, fig. 1, are as follows: (1), 2.3 by 2.8 mm.; (2), 3.4 by 3 mm.; (3), 4.2 by 4 mm.; (4), 5.4 by 5 mm. The thickness varies, being usually, but not invariably, greater through the center. In the vertical section, illustrated by plate 4, fig. 7, the thickness through the center is about 1 mm., and at the edge about 0.25 mm. Vertical sections of several specimens (paratypes) are illustrated by plate 5, fig. 2. The edges are either rounded or truncate. The specimens show externally two kinds of markings, the most conspicuous being slightly impressed lines which represent successive positions of the growing edge and mark the position of chamber walls. They are illustrated by plate 4, figs. 1-6. Their spacing is not uniform. In addition to the coarser subconcentric markings, there are very minute lines which are approximately perpendicular to the former lines. These fine markings have been worn off the surfaces of many specimens.

The apertures occur on the anterior surface of the growing edge and are indefinite. Many specimens were examined to ascertain if there were an apertural slit such as that in *Cyclammina* but none could be discovered. The apertural surface may extend to the place of contact with the inner part of the test or the lateral walls may meet on its proximal side and separate it slightly from the next inner coil.

The finer structure as seen in a thin section in the median plane of a specimen is illustrated by plate 5, fig. 1. The proloculum is a single pear-shaped cell 1 by 0.9 mm. in diameter. The first chamber occupies about 1⅓ turns and is succeeded by nine chambers. The lines between successive chambers of the section represent chamber walls and correspond to the impressed lines on the outside of the test, but the earlier chambers are concealed as stated above. The width of the chambers, measured radially, is not uniform, ranging in this specimen from 0.25 to 0.5 mm.

The structure within the chambers is well shown by the illustration, plate 5, fig. 1. In the figure the skeletal deposit is dark and the infilling light. The internal structure is composed of elements arranged along intersecting lines, as seen in a section in the median plane, so as to produce a criss-cross pattern. In the first three chambers one set of lines is approximately parallel to the inner and outer walls of the chamber, and the other set makes nearly a right angle with the former. In the later formed chambers one set of lines extends from the outside chamber wall forward at an angle of approximately 35° with the periphery, while the other set extends from the inside chamber wall forward at an angle of approximately 30° with the inside wall. The angle between the two sets of lines ranges from about 110° to about 135°. It is not constant and may be said to range from somewhat more than 90° to as much as 135°. In this section the elements of the structure appear as lines but in reality they are plates, as may be seen in the vertical sections. The two sets of structural elements are composed of very fine-grained arenaceous material in a dark cement. In a section of a specimen from another locality, J. 102 M. (see below for explanation), there is some brownish substance which appears to be chitin. The thickness of the structural elements ranges from about 0.025 to 0.05 mm., with interspaces of approximately the same width.

A vertical section of a cotype is illustrated, plate 4, fig. 7, which shows how the initial part of test is covered by later additions. Plate 5, fig. 2, which illustrates a section of paratypes shows more clearly the way the younger overlap the older coils.

In vertical section the structural elements near the embryonic chamber are more or less sinuous and interrupted, with some anastomosis, without presenting a definite pattern, except that they are elongate along axes approximately vertical to the faces of the test. Near the periphery a distinct pattern is recognized. Three rows of spaces are formed, one near each face and one between the two others. The longer axes of the spaces are perpendicular to the

faces of the test and their ends are acute angles.

Although there is variation among specimens which may be regarded as normal megalospheric individuals, there are extreme forms that are abnormal and perhaps are teratologic. In a few specimens the end of the last coil has been prolonged in a straight line and produced a growth form similar to that of *Pseudocyclammina.*

The description so far applies to the very abundant megalospheric specimens. Some of the thinner specimens show the anterior edge of the apertural face extending around the test so that the two ends of the apertural edge meet and initiate cyclical growth. A few small thin specimens were sectioned in the median plan in the hope that they would be microspheric, but they were all megalospheric, and, except that they were thin, they showed no noteworthy peculiarities. The different stages can be followed through from the coiled to the cyclical growth-form. A set of specimens is figured to show the stages, but all of them can be seen on the large specimen illustrated by plate 4, fig. 6. Unfortunately the distinctive features of the central part of the test of this specimen are not clearly shown in the figure. Sections in the median plane and vertical sections reveal a structure similar to that of the smaller specimens of non-cyclical growth. It is therefore, necessary to conclude that both kinds of specimens belong to the same species. It appears probable that the large specimens of cyclical growth-form are microspheric, but there were too few specimens to permit making the sections needed to ascertain the embryonic features. The largest perfect specimen, plate 4, fig. 6, is 50 mm. in diameter.

Geologic horizon and localities.—"Yellow limestone", middle Eocene at the following localities:

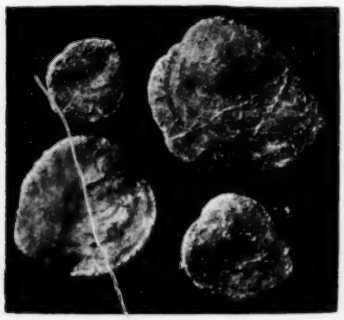
Boundary of the parishes of St. Elizabeth and Manchester. J. 500 M., Spice Grove; J. 501 M., Spice Grove, near head of spring; J. 503 M., Gentle Hill, at 1100 ft. descent; J. 505 M., Phantillands parochial road, 1.8 mi. from the main road.

Parish of St. Catherine, J. 507 M., Coco walk.

Parish of Clarendon, Peace River district, J. 603 M., Cumberland road at 9.5 mi.; J. 604 M., Peace River road, top of Whitney Valley, ascent on west side; J. 605 M., Davyton road at 4⅞ mi.; J. 608 M., bridle track near Whitney Valley, 1⅛ mi. from Peace River.

Specimens of both the megalospheric and microspheric forms were obtained at every locality listed above except J. 603 M., where only megalospheric specimens were collected.

North Manchester, J. 102 M., Belvedere, Christiana, near lignite bed, in excavation for shallow well. Only megalospheric specimens



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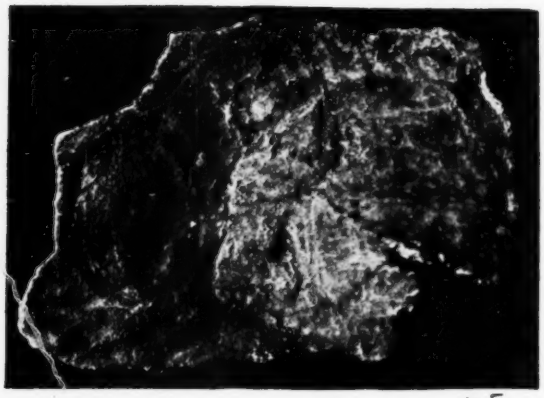

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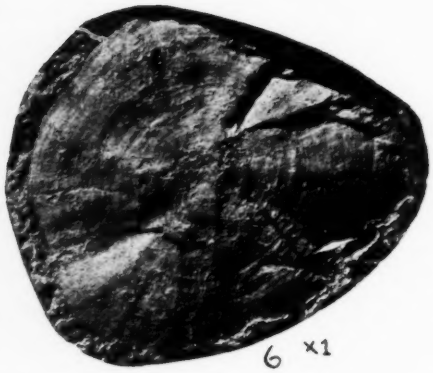

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were obtained at this locality. The matrix is originally a slate-colored clay, which after weathering is yellowish or brownish.

Species associated with *Yaberinella jamaicensis* are *Dictyoconus codon* Woodring, *Discocyclina* sp., *Alveolina* sp., *Antilloseris cantabrigiensis* (Vaughan), and *Dendracis cantabrigiensis* Vaughan. The beds containing *Yaberinella jamaicensis*, on the basis of the two species of corals listed above, may be correlated with that part of Hill's Cambridge "beds" as exposed near Cambridge station, south of Montpelier, St. James Parish.[1] Unfortunately, since Hill's Cambridge "beds" includes deposits of both Cretaceous and Eocene age, the name does not apply to a stratigraphic unit and cannot be retained in stratigraphic nomenclature.[2]

Cotypes and Paratypes.—U. S. National Museum. Specimens also returned to Doctor Matley, for deposit in the British Museum (Natural History). Duplicate topotypes, Scripps Institution.

Affinities of Yaberinella.—These have already been indicated, viz., that the genus is related to *Dictyopsella, Cyclammina, Choffatella,* and *Pseudocyclammina.* The papers by Schlumberger and Yabe and

[1] Vaughan, T. W., Mus. Comp. Zool. Bull. 34, no. 1, 1899, pp. 230, 231.
[2] Trechmann, C. T., Geol. Mag., vol. 59, 1922, pp. 422-431.

EXPLANATION OF PLATES

(The locality numbers are explained in the foregoing text)

PLATE 4

Yaberinella jamaicensis Vaughan n. gen. et sp.

FIG. 1.—Side views, ×5, of four cotypes, megalospheric specimens, from locality J. 505M.

2, 2 *a*.—Two views of the same specimen from locality J. 102M; fig. 2, side view, ×5; fig. 2 *a*, part of surface, ×20, to show the very fine striations.

3.—Side view, ×5, of a megalospheric specimen from locality J. 505M., for comparison with fig. 4 of a specimen that has attained cyclical growth.

4.—Side view, ×5, of a microspheric specimen from locality J. 505M. The specimen is broken but shows the early spiral and later cyclical growth.

5.—Side view, ×5, of a microspheric specimen from locality J. 604M, which shows both spiral and cyclical growth.

6.—Side view, natural size, of a large microspheric specimen from locality J. 501M.

7.—Vertical section, ×20, of a cotype, a megalospheric specimen, from locality J. 505M.

Hanzawa[3] referred to below should be consulted for purpose of comparison. *Dictyopsella* is the most nearly related genus, but its internal structure is not nearly so complex as that of *Yaberinella*, which represents the highest known development in this group of foraminifera.[4]

Name.—It gives me pleasure to dedicate this genus to Prof. Hisakatsu Yabe who has done much toward making known the foraminiferal faunas of Japan and tropical Pacific Islands, in addition to having conducted many other important geologic and paleontologic researches.

[3] Schlumberger, C., Note sur quelques foraminiferes nouveaux ou peu connus du Cretace d'Espagne. France Soc. geol., 3d ser., vol. 27, 1899, pp. 462, 463, pl. 8, figs. 5, 7; pl. 11, fig. 20. Dictyopsella and its type species are both credited to Munier-Chalmas.

Yabe, H., and Hanzawa, S., Choffatella Schlumberger and Pseudocyclammina, a new genus of arenaceous foraminifera. Tohoku Imp. Univ. Sci. Repts., 2d ser. (Geology), vol. 9, no. 1, pp. 9-11, 1 pl., 1 text-fig., 1926.

[4] My thanks are extended to Dr. Jos. A. Cushman for kindly calling my attention to the description of Dictyopsella.

EXPLANATION OF PLATES

PLATE 5

Yaberinella jamaicensis Vaughan n. gen. et sp.

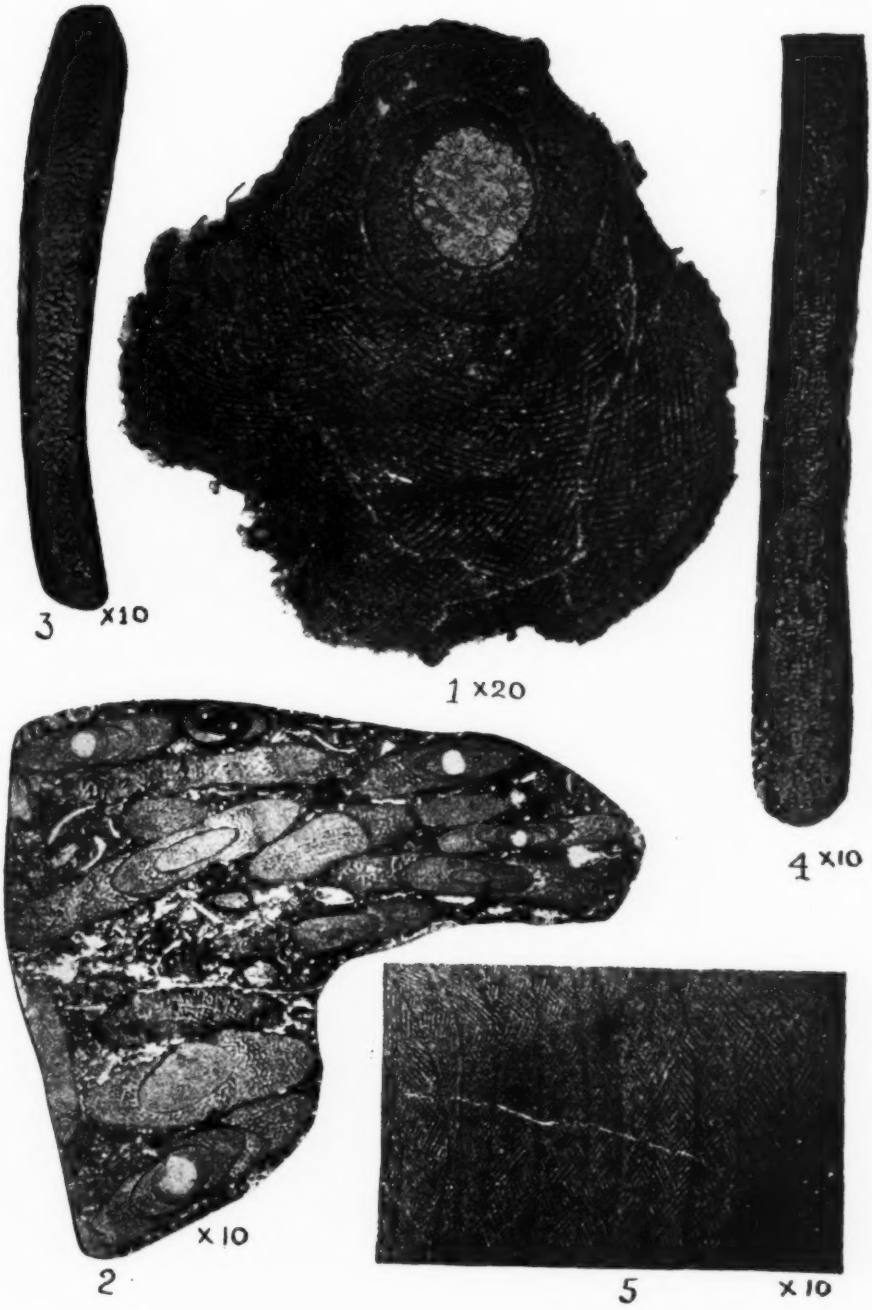
FIG. 1.—Horizontal section, ×20, of a cotype, a megalospheric specimen, from locality J. 505M. The very fine surface striations are shown on both the right and left hand sides of the figure.

2.—Vertical section, ×10, of megalospheric specimens from locality J. 500M.

3.—Vertical section, ×10, of microspheric specimen from locality J. 501M.

4.—Obliquely vertical section, ×10, of microspheric specimen from locality J. 501M.

5.—Horizontal section, ×10, of microspheric specimen from locality J. 501M.


3 x10
1 x20
4 x10
x 10
2
5
x 10

AN OBSERVATION ON THE RANGE OF THE GENUS HANTKENINA

HENRY V. HOWE
Louisiana State University

ABSTRACT

The range of the genus *Hantkenina* is extended to the Oligocene and one new species is described.

The genus *Hantkenina* is one of the most striking of the Upper Eocene foraminifera of the Gulf Coastal Plain of America. It has been taken as one of the most characteristic guide fossils of the Upper Eocene since its description in 1924.

For the past two years the writer has had a number of specimens of *Hantkenina* from the Oligocene limestones at Old Fort St. Stephens, Alabama, where it is really one of the commonest of the smaller foraminifera. There was just a suspicion of doubt, however, as to its Oligocene age because of a suggested occurrence of Jackson Eocene material at the base of the bluff.[1] The foraminiferal material from this bluff discussed here was collected by the writer and certainly came from high enough up the bluff to be free from any Eocene contamination. This is further borne out by the fact that the remainder of the foraminifera are clearly Lower Oligocene.

However, the suspicion that *Hantkenina* did not really occur in the Lower Oligocene has been completely removed recently by the discovery of this genus at the type locality of the Red Bluff Oligocene at Hiwannee, Mississippi.

The commonest *Hantkenina* of the Red Bluff Clay is *Hantkenina alabamensis*. It is quite abundant in the Red Bluff beds at Old Fort St. Stephens and occurs sparingly at the type locality of the Red Bluff Clay at Hiwannee, Miss. There is, however, another type present at Old Fort St. Stephens which occurs in the basal limestones overlying the typical Red Bluff Clay, and which appears to be a development from *Hantkenina brevispina*. It is different from all

[1] Geol. Surv. of Alabama, Special Report no. 14, 1926, p. 283.

other Hantkeninas in that its chambers are globose with short spines and the last few chambers increase in size so rapidly that they overlap the preceding chamber and almost completely cover up the spine of the preceding chamber.

Family HANTKENINIDAE

Genus HANTKENINA Cushman, 1924

HANTKENINA ALABAMENSIS Cushman

Figure 1

Hantkenina alabamensis CUSHMAN, Proc. U. S. Nat. Mus., vol. 66, 1924, p. 3, pl. 1, figs. 1-6, pl. 2, fig. 5.

The specimen whose photograph is reproduced here came from the marls at the base of the Oligocene at Old Fort St. Stephens Bluff, Alabama. Similar specimens have been found at the type locality of the Red Bluff Clay at Hiwannee, Miss. The measurements of this specimen are:

Diameter without spines 0.45 millimeter; with spines 0.72 millimeter.

Fig. 1

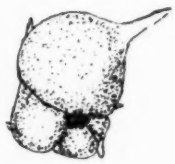


Fig. 2.

HANTKENINA INFLATA Howe, n. sp.

Figure 2

Test planospiral, adult coil with 4 or 5 chambers, periphery somewhat lobulate, wall very finely punctate, smooth, granular near aperture, spines short, hollow, pointing anteriorly, chambers globular and so inflated that each chamber almost completely covers the spine of the preceding chamber, aperture comparatively small, tripartite, at the base of the apertural face.

Diameter without spines 0.58 millimeter; with spines 0.75 millimeter.

Holotype (Louisiana State University Museum, No. H. 16) from the limestones at the base of the Oligocene section Old Fort St. Stephen Bluff, Alabama.

MONOCERATINA: A NEW GENUS OF OSTRACODA FROM THE PENNSYLVANIAN OF OKLAHOMA

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ABSTRACT

In the following pages a brief description of a new genus of ostracoda is given. Examples of this genus are quite rare in the shales and limestones of Oklahoma. Some discussion concerning the orientation of the valves, also some points on the possible evolution of the species are given. Following this is a description of the new genus, species and a variety of the species. Figures illustrating the species and variety follow the text.

In studying the genotype of this new genus, *Monoceratina ventrale*, the following points have been noted in regard to occurrence, generic relationships and evolutionary changes. This interesting minute genus of ostracods is but rarely found in the shales and limestones of the Pennsylvanian formations of Oklahoma. When found this genus is almost invariably represented by single valves which are usually deformed. The finding of a complete carapace that is not deformed in some way is almost impossible. The carapaces denoting the genus and variety herein described are both more or less deformed and were only found after a great deal of work and a vast amount of material in the form of shales and limestones had been gone through. This deformation has caused the apparent overlap on the hinge line. *Monoceratina*, aside from its novel form, is interesting in that it is one of the few representatives of the *Primitiidae* found in the Pennsylvanian. This great family, which was so prominent in the Ordovician and the Silurian, started its decadence in the Devonian and was all but extinct at the close of the Pennsylvanian. Some discussion may arise concerning the orientation of the valves. However, the following points will tend to clear up this difficulty. In considering the horn-like processes it does not seem likely that they are brood pouches because of their peculiar shape. It seems much more reasonable to suppose that these processes are ornaments which in some way reflect the soft parts of the ostracod. As a result it is be-

lieved that the orientation may better be seen by removing the horn-like ornaments and considering the carapace without them. It will be observed that in *Monoceratina ventrale* a faint *Primitia*-like sulcus is situated a little to one side of the median half of the valve. The half containing this sulcus is arbitrarily chosen as the posterior half. Also, the half which contains the sulcus is much thicker at its extremity while the anterior end is very acutely angled where the valves join. Then too, the end which contains the sulcus is the blunt end, which is another good point in making this the posterior end. Furthermore, it will be observed in the side view that there is a very pronounced backward swing in the outline of the valves toward the thicker end. It is obvious that since the valves do not contain any lobation and as the sulcus does not contain any swing to the posterior end, these points cannot be used in orientating the valves. From the foregoing points little room for doubt is left as to the correct orientation and as a result the two figures, 1*a* and 2*a*, are right valves.

Considerable evolution may be observed between *Monoceratina ventrale*, which comes from the base of the Pennsylvanian, and *Monoceratina ventrale*, variety *magnum*, which comes from the middle part of the Kansas City formation, which formation is well up in the Pennsylvanian. It will be seen that the variety *magnum* is larger, has lost all trace of a sulcus, has the horn-like processes more highly specialized, both in being more prominent and in assuming a decided papillate outline, and that the concentric pitted pattern observed in *Monoceratina ventrale* is completely absent in the variety *magnum*. These changes between the two forms may not be evolutionary, but rather they may be atavisitic. This point cannot be definitely settled as we do not know just what these ornaments or expressions on the valves may reflect when the soft parts of the ostracod are considered.

Superfamily BEYRICHIACEA

Family PRIMITIIDAE

Genus MONOCERATINA new genus

MONOCERATINA VENTRALE, new species

Figs. 1 *a*, right valve; 1 *b*, ventral aspect; 1 *c*, dorsal aspect

All figures are magnified 30 diameters

Carapace, sub-oblong, quite tumid, maximum height slightly anterior to the median half, maximum thickness is well down on the antero-ventral side and approximately in the plane of the maximum height. Hinge line is straight, on the posterior extremity the ventral

margin is boldly rounded and meets the hinge line at a very obtuse angle, on the ventral side the margin is almost parallel to the dorsal margin for about three-fourths of the length of the hinge line. However, the ventral margin here represented is at a very slight angle to the hinge line and will gradually meet it posteriorly if produced. On the anterior part of the ventral margin there is a rounded obtuse angle toward the hinge line; the anterior part of this obtuse angle is slightly concave, after which it boldly curves inward to meet the hinge line at an obtuse angle. The anterior obtuse angle is of a lesser degree than the posterior one. This whole anterior part of the ventral margin is

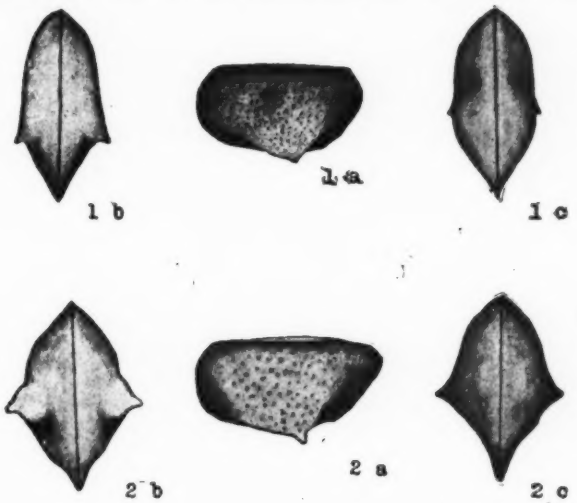


Fig. 1. *Monoceratina ventrale* new species, *a*, right valve; *b*, ventral aspect; *c*, dorsal aspect. Fig. 2. *Monoceratina ventrale*, var. *magnum* new variety, *a*, right valve; *b*, ventral aspect; *c*, dorsal aspect. All × 30.

somewhat similar to the prow of a vessel. In fig. 1*c* the dorsal aspect also brings out very nicely the outline of the hull of a vessel. All the carapaces and valves studied have shown the valves to be nearly equal or as much so as possible. There is a tendency of the left valve to be slightly grooved on the dorsal and ventral sides so that it may receive the right valve. This character is extremely variable and many valves do not show it. This variability is probably due to poor fossilization. About five-eighths of the distance toward the posterior end a faint *Primitia*-like sulcus may be observed which extends toward the hinge line from about the middle of the valve and almost touches this line. Both valves have a general pitted surface, which gradually fades anteriorly and posteriorly and is very prominent on the horn-

like protuberances. This pitted character is concentrically arranged about one pit in the sulcus on some forms, but it is not always present, which again may be due to poor fossilization. The horn-like projection is the most interesting thing on these minute forms. In this species it has more the character of a flange and first develops at about seven-eighths of the distance posteriorly. This flange gradually develops until at about three-fourths of the distance posteriorly it has projected downward and outward until it is on a level with the keel of the ventral margin. The maximum development is about three-eighths of the distance posteriorly, at which point it is well below and away from the ventral keel. At this point it terminates in a sharp little horn. Anteriorly from this point the horn-like flange drops back to the carapace at almost right angles and rapidly fades into the very sharp anterior keel of the ventral margin. There is a very pronounced tendency along the whole ventral margin for the valves to meet at a very acute angle which appears almost as a keel or flange.

Maximum length 0.8 mm., height 0.5 mm., width 0.5 mm. There is no other genus that is closely related to this genus, but there are some which bear some superficial similarities.

Aechmina (Jones and Holl) shows a superficial similarity to *Monoceratina*, but the radical change in position of the spine, which is on the dorsal side in *Aechmina*, is at once apparent.

Monoceratina ventrale is found in the Wapanucka limestone at sec. 28, T. 3 N., R. 7 E., Pontotoc County, Oklahoma.

Holotype U. S. National Museum number 71812.

MONOCERATINA VENTRALE var. MAGNUM, new var.

Figs. 2 *a*, right valve; 2 *b*, ventral aspect; 2 *c*, dorsal aspect

All are magnified 30 diameters

Carapace, sub-oblong, quite tumid, hinge line straight. The posterior extremity of the ventral margin is boldly curved and meets the hinge line at an obtuse angle. The ventral part of the ventral margin is almost parallel to the hinge line, but it is slightly inclined to it and will meet it if produced posteriorly. The anterior part of the ventral margin is a slightly concave line between two obtuse angles which are well-rounded. The anterior obtuse angle formed by the junction of the hinge line with the ventral margin is of greater degree than the posterior obtuse angle formed by the same junction. The anterior part has the same prow-like appearance noted in the genotype, however, it is more pronounced in this variety. Maximum thickness and height are very close to the middle portion of

the valves, but are slightly anterior to it. The left valve is grooved slightly on the dorsal and ventral portions to receive the right valve. This character is obsolete in some cases, probably due to poor fossilization. Well preserved specimens have a pitted surface which gradually dies out on the anterior and posterior extremities. However, the protuberances are well pitted. The junction of the valves along the whole ventral margin shows a marked tendency to meet at a very acute angle, thus producing a keel, which in the anterior portion is very pronounced. The protuberances are well developed in this species and are first seen to develop at about three-fourths of the distance from the anterior extremity. From this point they rapidly develop and extend outward from the carapace and are level with the keel at five-eighths of the distance posteriorly from the anterior extremity. From here they rise in papillate form to a final horn which points away from the carapace and slightly toward the anterior end. From this point, which is slightly anterior to the middle portion of the valves, these protuberances rapidly drop back to the carapace and completely fade out at a point about three-eighths of the distance from the anterior end. The papillate tendency is very well shown in the figure 2*b*.

Maximum length 0.9 mm., maximum height 0.5 mm., maximum width 0.7 mm.

The variety *magnum* was collected from the middle portion of the Drum Group, which in turn is represented in the middle portion of the Kansas City formation in Kansas.

Samples in which var. *magnum* was found were collected in Sec. 11 T. 19 N., R. 10 E., Tulsa County, Oklahoma.

Holotype, U. S. National Museum, number 71813.

A NEW FAUNA FROM THE COOK MOUNTAIN EOCENE NEAR SMITHVILLE, BASTROP COUNTY, TEXAS

W. ARMSTRONG PRICE and KATHERINE VAN WINKLE PALMER[1]

ABSTRACT

A new Cook Mountain molluscan fauna composed of a few species common to typical St. Maurice and Claiborne localities and a large number of individuals of 5 new species and 1 new variety referred to the genera *Acirsa*, *Bullia*, *Pitaria* and *Trinacria*. The abundance of *Pitaria (Rhabdopitaria) astartoides* seems to indicate a possible close affinity with the Cook Mountain fauna of the Rio Grande valley.

The new faunal locality is near one of Deussen's Colorado River Cook Mountain faunal localities but the lithology of the two is different, although both faunas occur in glauconitic beds.

The stratigraphic relationships of the several Cook Mountain fossil localities along Colorado River are obscured by concealed intervals and structural irregularities. Faulting occurs in the vicinity and possibly in the section described.

INTRODUCTION

On the south bank of the Colorado River at the mouth of Gazley Creek, in the west edge of the town of Smithville, Bastrop County, Texas, is an exposure of fossiliferous, glauconitic, gray sandstone containing a Cook Mountain fauna. In respect to the numbers of individual shells, this fauna is composed chiefly of new species of mollusca.

Gazley Creek takes its name from the Thomas J. Gazley original land survey in which the western portion of the town of Smithville is situated. The creek is about 3½ miles long and flows northeasterly through the western edge of the town, emptying into the Colorado River at a point about 1,600 to 2,000 feet above the highway bridge over the river at Smithville.

A few hundred feet above the bridge, at the south bank of the river and forming a shoal in the stream, is a prominent outcrop of a 15-foot group of fairly hard, fossiliferous greensand marls, weathering nodular and red to yellow-brown. The marls are interbedded with sand, sandy clay and brownish-red lignitic clay. This outcrop has been described by Deussen[2] who gives a 12-foot section

[1] The senior author has examined the locality. The junior author has made the paleontological determinations.

and a list of Cook Mountain fossils from the marl beds, as identified by Cooke and Vaughan.

LITHOLOGY

The sandstone at the mouth of Gazley Creek, although weathering to a soft shell marl where it is in contact with the river water, differs markedly in appearance from the marl group of Deussen's section. The glauconite of the Gazley Creek sandstone does not color the rock red on weathering.

The sand from the more fossiliferous, lower portion of the Gazley Creek stratum has been described by Esther Richards Applin in a report to the writer as being "very angular and moderately even in size, almost entirely clear quartz. No forams are present. About 25% small nodules of dark green glauconite present."

At the eastern edge of the exposure the sandstone bed is slightly bevelled, the deposition of the overlying non-fossiliferous sands and brown clays having been accompanied locally by a small amount of erosion. In the upper portion of the fossiliferous stratum are areas of intraformational conglomerate, containing small polygonal blocks of argillaceous calcareous sandstone and of lignite. This part of the stratum is hard, the sandstone in part finely laminated, and the shells chiefly fragmentary and badly eroded.

STRATIGRAPHIC AND STRUCTURAL RELATIONS

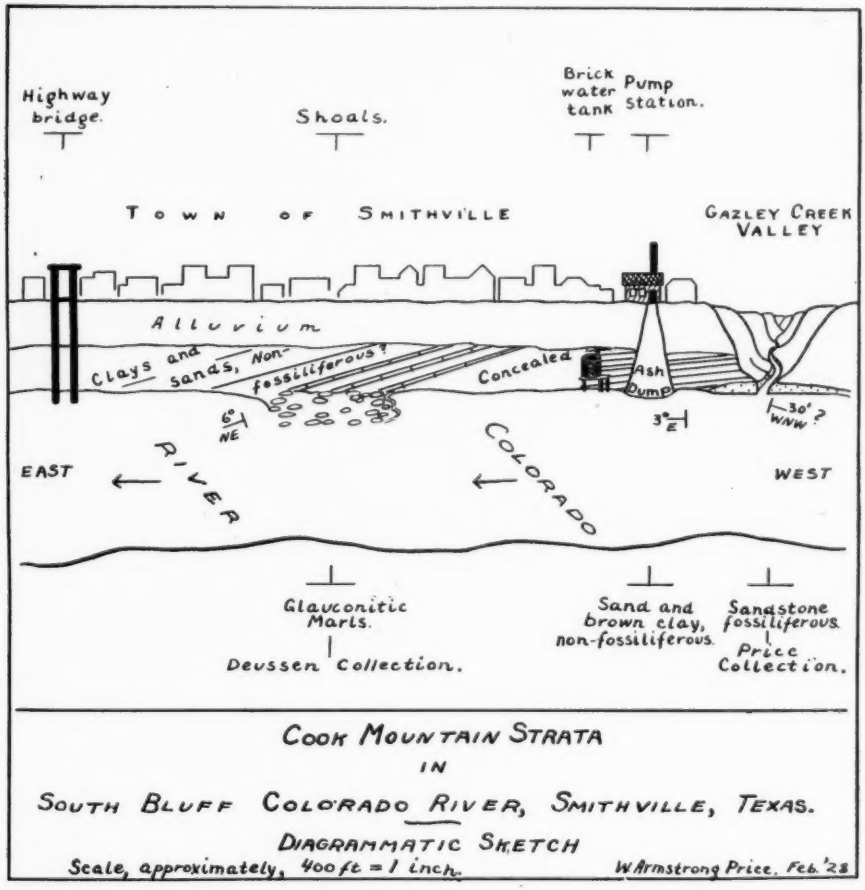
The field relations of the sandstone containing the new fauna and the glauconitic marls of Deussen's section are shown in the sketch, Figure 1. The stratigraphic relationship of the two fauna is, unfortunately, obscure. The same must be said of the various outcrops of Cook Mountain faunal beds in Bastrop County along the Colorado River with respect to each other. Wide areas of concealed beds separate areas of visible structure.

A non-fossiliferous sand and clay unit overlies the Gazley Creek fauna. If the stratigraphic sequence is a normal one, the marls of Deussen's section lie immediately above the non-fossiliferous unit and the latter is some fifty feet in thickness. The six-degree dip at the shoals is, however, high for the area and is suggestive of faulting. The high dip persists for several miles along the outcrop of the marl group to the southwest, in the hills along the east side of Gazley Creek valley, where there are exposures which appear to exhibit drag dips and faults with vertical displacements ranging from 1 to 15 feet.

[2] Deussen, Alexander, U. S. Geol. Survey, Prof. Paper No. 126, p. 70, 1924. Fossil list pp. 64-65.

A well-defined fault, with drag dips and a half-acre outcrop of spongy, calcareous tufa, which seems to have been a fault-line spring deposit, was seen 2½ miles south of Smithville.

The Gazley Creek sands and clays were not found in direct contact



with the marl group of the shoals. A gap of one hundred feet along the river bluff in which the strata are concealed intervenes between the outcrops of the two groups. This concealed interval occupies the full height of the river bluff just east of the small brick water tank on the bluff below the town pumping plant. A fault may exist at this point.[3]

[3] Mr. Frank Rundus of Smithville states that he found a breccia at the point now covered by the ash dump of the pumping plant. It would appear from his description of the specimen that it was from the intraformational breccia of the Gazley Creek faunal sandstone, and not from an indurated fault breccia.

There appears to be a change in dip between the highway bridge at Smithville and the west bank of Gazley Creek. The dip at the shoals is given by Deussen as "downstream 6° N 40° E." The sandstone and the sand and clay unit above it in the east bank of Gazley Creek show an eastward dip component of about 3° while the sandstone west of the mouth of the creek appears to show a dip component of 30′ west-northwest. The dips in the faunal sandstone are, however, not satisfactorily exhibited.

If three points on the shoals group, as it has been identified by lithology, be taken—one north of Smithville in the hills north of the river, one southwest of the town along the valley of Gazley Creek and the shoals outcrop itself—the dip and strike across the river valley at Smithville become N 25° E 1½° E.

A thickness of 3 or 4 feet of the fossiliferous sandstone was seen above water level when it was visited in January, 1927. The outcrop was exposed for about 100 feet along the south bank of the river on each side of the creek mouth and for a like distance up the east bank of Gazley Creek.

PALEONTOLOGY

The sand is very fossiliferous, composed of masses of specimens of a few species of mollusca. Although the sand was sifted and examined carefully no foraminifera were found. The fossils in the harder rock are fragmentary and badly eroded. The species in the following list were identified:

Acirsa (Acirsella) henryleai n. sp.
Architectonica alveatum Conrad
Architectonica sp.
Bullia altile harrisi n. var.
Bullia sp. aff. ellipticum Whitefield
Lacinia alveata Conrad
Levifusus cf. trabeatus Conrad
Sinum declivis Conrad
Corbula alabamiensis Lea
Nucula magnifica mauricensis Harris
Ostrea cf. sellæformis Conrad var.
Pitaria (Pitaria) gazleyensis n. sp.
Pitaria (Pitaria) juliæ n. sp.
Pitaria (Rhabdopitaria) astartoides (Gardner)
Pitaria (Rhabdopitaria) pricei n. sp.
Trinacria adamsi n. sp.

The age of the deposit is that of the Cook Mountain formation of the Middle Eocene. Although there occur in the material species

which are typical of St. Maurice and Claiborne Eocene localities elsewhere, the forms which make up the greatest mass of the sand are new and distinct. The most common species are: *Acirsa* (*Acirsella*) *henryleai*, n. sp., *Bullia altile harrisi* n. var., *Pitaria* (*Pitaria*) *juliæ* n. sp., *Pitaria* (*Rhabdopitaria*) *astartoides* (Gardner), *Pitaria* (*Rhabdopitaria*) *pricei* n. sp. and *Trinacria adamsi* n. sp. The subgenus of *Pitaria, Rhabdopitaria* is known as yet from three species only. The species are *P.* (*Rhabdopitaria*) *winnensis* Harris[4] from "Marble Quarry", west of Winnefield, Texas, St. Maurice Eocene, *P.* (*Rhabdopitaria*) *astartoides* (Gardner)[5] described from near Laredo, Webb County, from Starr County and from Zapata County, Texas, and *P.* (*Rhabdopitaria*) *pricei* n. sp. of the present locality. *P.* (*Rhabdopitaria*) *astartoides* is also very abundant at the present locality. It is this species which seems to indicate a possible close affinity with the Cook Mountain formation described by Trowbridge[6] in Webb, Starr and Zapata Counties near the Rio Grande, Texas.

The material of the present paper was collected by W. Armstrong Price and Julia A. Gardner in 1927.

Additional material from a collection of John E. Adams of The California Company, Colorado, Texas, was incorporated in the original lot.

The authors wish to express their thanks to Mr. Adams for the use of that material.

The species described and listed are all from the same locality—the east bank of the mouth of Gazley Creek, south side of Colorado River, Smithville, Bastrop County, Texas.

The holotypes, duplicate material and specimens figured are all deposited in the Eocene collection of Professor G. D. Harris, at Cornell University.

PELECYPODA

Genus NUCULA Lamarck, 1799

NUCULA MAGNIFICA MAURICENSIS Harris

Plate 7, figs. 6, 8

Nucula magnifica mauricensis HARRIS, 1919, Bull. Amer. Pal., vol. 6, no. 31, p. 124, pl. 26, figs. 4-6.

A few fragments of shells and small specimens of this species

[4] Harris, G. D., Bull. Amer. Pal., vol. 6, no. 31, p. 147, pl. 46, figs. 9-13, 1919 as Meretrix.

[5] Gardner, Julia, with Trowbridge, A. C., A Geologic Reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande, U. S. Geol. Survey, Prof. Paper, No. 131-D, pp. 95, 96, 113, pl. XXXII, figs. 4-7, 1923.

[6] Trowbridge, A. C., ibid, pp. 95, 96.

occur. The species belongs to the *Nucula magnifica* Conrad stock. The shells apparently did not attain at the Gazley Creek locality the large size of that species. It is difficult to compare the broken and small material with specimens of *N. magnifica* and its varieties to see which of the Gazley Creek forms are most nearly equivalent in stages of growth. The specimens differ from the *Nucula* sp. Gardner[7] in the shape of the posterior end. The Gazley Creek material has the posterior end more pointed. The shells are like the *Nucula* sp. specimens of Gardner in size and in having the fine, radiating lines on the outer surface.

Dimensions.—5 mm., length; 4 mm., height; 1.5 mm., semidiameter.

Genus TRINACRIA C. Mayer, 1868

TRINACRIA ADAMSI Palmer, n. sp.

Plate 7, figs. 1, 2, 5

Description.—Shell smooth, inequilateral, rectangular; posterior end truncated with a straight, oblique, posterior margin; in young specimens 2 mm. in length, the posterior margin is nearly vertical; anterior end rounded; posterior, dorsal area concave with a slight, umbonal groove extending to the margin of the shell; ventral and dorsal lines nearly parallel; surface smooth except for lines of growth.

The distinct characters of this species are its rectangular shape with the wide, posterior truncation and the concavity in the posterior, dorsal region.

The species is fairly abundant in the Gazley Creek sand.

Named in honor of John E. Adams who donated generously material from the Gazley sand.

Dimensions.—6.5 mm. length; 5 mm., height; 1.5 mm., semidiameter.

Genus PITARIA Römer, 1857

PITARIA (PITARIA) GAZLEYENSIS Palmer, n. sp.

Plate 6, figs. 8, 11, 12

Description.—Shell medium in size; thick; umbo broad; circular in shape; posterior end broad; lunule large, impressed and bounded by an incised line; inner margin smooth; a slight groove occurs along the posterior, inner margin; surface smooth or with fine, concentric striæ, the striæ are developed better posteriorly.

The external surface of the shell was ground in a fairly large area, seen on figure 12, plate 6, to determine whether the inner surface

[7] Gardner, Julia, Prof. Paper, U. S. Geol. Sur., no. 131-D, p. 109, pl. XXIX, fig. 3, 1923.

would reveal the radiating striæ of *Rhabdopitaria.* The radiating lines are absent as well as crenulations on the inner margin.

In shape this species approaches *P. trigoniata bastropensis* (Harris).[8] Both species are circular with fine, concentric lines. *P. trigoniata bastropensis* has the lines developed more than in *P. gazleyensis.* Prof. G. D. Harris kindly compared the holotype of *P. gazleyensis* with the syntypes of *P. trigoniata bastropensis* at the Texas State Museum. He believes that there is a difference in shape of the two forms which warrants the separating of the two specifically. *P. gazleyensis* is broader posteriorly and the shell is more orbicular than *P. trigoniata bastropensis.*

Dimensions.—33 mm., length; 31 mm., height; 12 mm., semidiameter.

PITARIA (PITARIA) JULIAE Palmer, n. sp.

Plate 6, figs. 2, 7

Description.—Shell small, longer than high; umbones very small; posterior end narrower than the anterior; the anterior end slopes straight and obliquely from the umbo; lunule sunken; the line bounding the lunule obscure; shell smooth; concentric ribs may be partially smooth anteriorly; pallial sinus triangular; inner margin smooth.

This species differs in shape from young specimens of *P. pricei* n. sp. and *P. astartoides* (Gardner) with which it is associated so abundantly. It is more elongate than those two species.

In shape the species approaches that of *Callista perovata lisbonensis* (Harris)[9] from the St. Maurice Eocene of Alabama.

It differs from that species in being less produced anteriorly and in being more convex. The pallial sinus of *C. perovata lisbonensis* is the typical *Callista* biangulate sinus.

Named in honor of Dr. Julia Gardner of the United States Geological Survey.

Dimensions.—9.5 mm., length; 6.5 mm., height; 2 mm., semidiameter.

Subgenus RHABDOPITARIA Palmer, 1927

Rhabdopitaria PALMER, 1927, Pal. Amer., vol. 1, no. 5, p. 211, pl. XLIV, figs. 15, 16.

Description.—Shell robust in the genoholotype, *R. astartoides* (Gardner)[10] but thin in other species; inner margin crenulated, inner

[8] Harris, G. D., Bull. Amer. Pal., vol. 6, no. 31, p. 148, pl. 47, figs. 4-6, 1919.
[9] Harris, G. D., Bull. Amer. Pal., vol. 6, no. 31, p. 137, pl. 43, figs. 8-9, 1919 as Meretrix.
[10] Gardner, Julia, Prof. Paper, U. S. Geol. Survey, no. 131-D, p. 113, pl. XXXII, figs. 4-7, 1923.

margin on young specimen of 3 mm. and smaller of the genoholotype crenulated; some species which have the inner margin crenulated on adult shells do not show the crenulations on the young specimens of that size; outer surface smooth; worn surfaces reveal an underlying structure of radiating lines. Other characters as described in the original reference.

This subgenus was described as referred in the synonymy from incomplete data on the genoholotype. As mentioned in the original description the combination of hinge character and radiating surface structure is unique and distinct from any form known. The genoholotype was given as *Callocardia astartoides* Gardner and the description of the subgenus taken from Dr. Gardner's description of that species. Since the description of the subgenus was written the material of the present paper was received. This material proved to be made up mainly of masses of *Rhabdopitaria astartoides* and allied species in all stages of growth. We take the opportunity to correct and complete the description of the groups. The description of the species gave the margin as entire. Our material reveals the inner margin as crenulated. This is the logical character to be accompanied by such numerous and heavy, radiating lines as are on portions of the middle layers of the shell.

This subgenus differs from *Omnivenus*, Palmer,[11] in having smooth nymphs. It is like that genus in the crenulated margin and hinge, *Omnivenus* has a well developed, corrugated nymph.

PITARIA (RHABDOPITARIA) ASTARTOIDES (Gardner)

Plate 6, figs. 1, 3, 4, 5, 6

Callocardia astartoides GARDNER, 1923, Prof. Paper, U. S. Geol. Survey, no. 131-D, p. 113, pl. XXXII, figs. 4-7.

Pitaria (Rhabdopitaria) astartoides PALMER, 1927, Pal. Amer., vol. 1, no. 5, pp. 30, 211, pl. XLIV, figs. 15, 16.

A very complete series of this species occurs in the material from Gazley Creek. *Pitaria* (*Rhabdopitaria*) *astartoides* (Gardner), *Pitaria* (*Rhabdopitaria*) *pricei* n. sp., *Pitaria juliae* n. sp., and *Acirsa* (*Acirsella*) *heuryleai* n. sp. make up masses of rock at this locality. When the harder masses break up, it forms a coarse sand composed chiefly of quartz grains and fragments of the four species listed.

The species is distinguished by its triangular, high shape, prominent stages of growth, conspicuous, radiating lines on worn, external surfaces and the crenulated, inner margin. Young specimens 3 mm.

[11] Palmer, Katherine V. W., Pal. Amer., vol. 1, no. 5, p. 115, 1927.

and smaller are more rounded posteriorly. They show the crenulated, inner margin.

Dimensions.—14.5 mm. length; 13.5 mm. height; 4.5 mm. semidiameter.

The species was described from the Cook Mountain formation of the Middle Eocene on the Rio Grande, near Laredo, Webb County and in Zapata County, Texas.

PITARIA (RHABDOPITARIA) PRICEI Palmer, n. sp.

Plate 6, figs. 9, 10

Description.—Shell medium, thin, broadly triangular with a truncated, pointed, posterior ventral end; beaks small; lunule long, cordate impressed and bounded by an incised line; inner margins crenulated; pallial sinus triangular; hinge typical; surface with numerous, fine, concentric lines which are raised above the lines of growth; resting stages conspicuous on some specimens as well as radiating lines on worn surfaces of the exterior. On adult specimens, there is a slight, concave line in front of the posterior, ventral point of the shell. This extends toward the umbo. Young specimens of 9 mm. and smaller do not show a crenulated, inner margin.

This species differs from *Pitaria astartoides* (Gardner) which is associated with it, in being broader, more pointed posterior ventrally, and in being thinner. It has the fine, concentric lines which *P. astartoides* does not have but it lacks the crenulated, inner margin on the young shells of that species. It does not have the numerous resting stages or the radiating structure on worn surfaces developed so conspicuously.

The species is named in honor of Dr. W. Armstrong Price by whom it was collected.

Dimensions.—24 mm., length; 20 mm., height; 5 mm., semidiameter.

GASTROPODA

Genus BULLIA Gray, 1835

BULLIA ALTILE (Conrad)

Plate 6, figs. 13, 14, 16

Ancillaria antile CONRAD, 1832, Fos. Sh. Tert. Form., p. 24, pl. 10, fig. 2.
Ancillaria subglobosum CONRAD, 1832, ibid, p. 25, pl. 10, fig. 3.
Anolax gigantea LEA, 1833, Cont. Geol., p. 180, pl. 6, fig. 193.
Ancillopsis antile CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 22.
Buccinanops altile COSSMANN, 1893, Ann. de Geol. et Pal., 12 liv., p. 33; COSSMANN, 1899, Essais de Pal. Comparée, 3 liv., p. 43.

The common species of the Gosport sand listed usually as *Ancilla altile* Conrad and *Ancilla subglobosum* Conrad approach generically most closely to *Buccinum laevissimum* Gmelin (*B. lævigata* Martini) the type of *Bullia* Gray.[12]

We consider *B. subglobosum* as a variety of *B. altile*. *B. altile* is the normal form. *B. subglobosum* has an excess of callus developed so the shell becomes more globose and the spire depressed. In the Sabine Eocene the form flattens ventrally. The callus develops a large nodular character above the posterior notch. In the Gazley Creek material specimens illustrate an extreme development of the callus and the flattening ventrally as shown on the Sabine Eocene specimens. These forms we describe as a new variety of *B. altile* Conrad.

BULLIA ALTILE HARRISI Palmer, n. var.

Plate 7, figs. 7, 11, 12, 15

Description.—Shell small, irregular in shape, flattened ventrally, protruded to the left; the anterior notch is as in *B. altile;* spire is usually depressed and enveloped in the callus; the callus spreads posteriorly and laterally and covers the greater portion of the shell; usually three distinct, large nodes or bumps occur, one on the inner lip just above the middle, one on the dorsal side of the body whorl and one laterally on the middle, left portion of the body whorl. Many specimens have the trinodular character developed strongly and the spire so enveloped in the callus that the true generic identity of the form is obscured. There are specimens which show the anterior notch and groove of *Bullia.*

Named in honor of Prof. G. D. Harris of Cornell University.

Dimensions.—17 mm., height; 14 mm., greatest diameter.

Genus ACIRSA Mörch, 1857

Subgenus ACIRSELLA de Boury, 1886

ACIRSA (ACIRSELLA) HENRYLEAI Palmer, n. sp.

Plate 7, figs. 3, 9, 10

Description.—Shell small, whorls eight or nine; sides of the whorls straight, only slightly convex at the sutures; protoconch broken; sutures distinct; aperture elliptical, entire, with a slight notch at the posterior end; surface sculptured with prominent, flat-topped uniform, concentric ribs with interspaces of about two-thirds the width of the ribs; the ribs on the body whorl are uniform in size over the whole of the body whorl; there are about ten, concentric ribs on the

[12] Gray, 1835, Griffith's Cuvier, t. 37 fide Tryon, 1882, Man. Conch., vol. IV, p. 206.

body whorl; on the lower whorls of the spire there are five, sometimes six, concentric ribs; on the upper whorls of the spire the concentric ribs number four; very often on the upper whorls of the spire nodular, axial ribs occur; on eroded specimens the concentric ribbing is absent but the upper, raised margin of the whorl just below the suture gives the aspect of a single rib on the shell. This appearance is that of the most common condition in which the species is found.

This species has the general form and appearance of *A. elegans* (H. C. Lea) from the Gosport sand of Claiborne Bluff, Alabama and might be confused easily with that form. Microscopic examination reveals a distinct difference in the character of the ribbing. The concentric ribs on *A. elegans* are wide with very narrow interspaces. The ribs on the basal portion of the body whorl are smaller with wider interspaces than those on the upper portion of the body whorl. On *A. henryleai* the interspaces are wide, about two-thirds the width

EXPLANATION OF PLATES

PLATE 6

FIG. 1.—*Pitaria (Rhabdopitaria) astartoides* (Gardner), right valve; 6 mm., length; 5.25 mm., height; 1.5 mm., semidiameter; to show pallial sinus.

2.—*Pitaria (Pitaria) juliae* Palmer n. sp., holotype; 7 mm., length; 5.5 mm., height; 2 mm., semidiameter; left valve.

3.—*Pitaria (Rhabdopitaria) astartoides* (Gardner), right valve; 9 mm., length; 8 mm., height; 2.5 mm., semidiameter; to show radiating lines.

4.—*Pitaria (Rhabdopitaria) astartoides* (Gardner), left valve to fig. 1.

5.—*Pitaria (Rhabdopitaria) astartoides* (Gardner), right valve; 13.5 mm., length; 12 mm., height; 3 mm., semidiameter.

6.—*Pitaria (Rhabdopitaria) astartoides* (Gardner), left valve; 13 mm., length; 12 mm., height; 3 mm., semidiameter; to show the prominent growth stages.

7.—*Pitaria (Pitaria) juliae* Palmer n. sp., same specimen as fig. 2 enlarged greatly to show hinge.

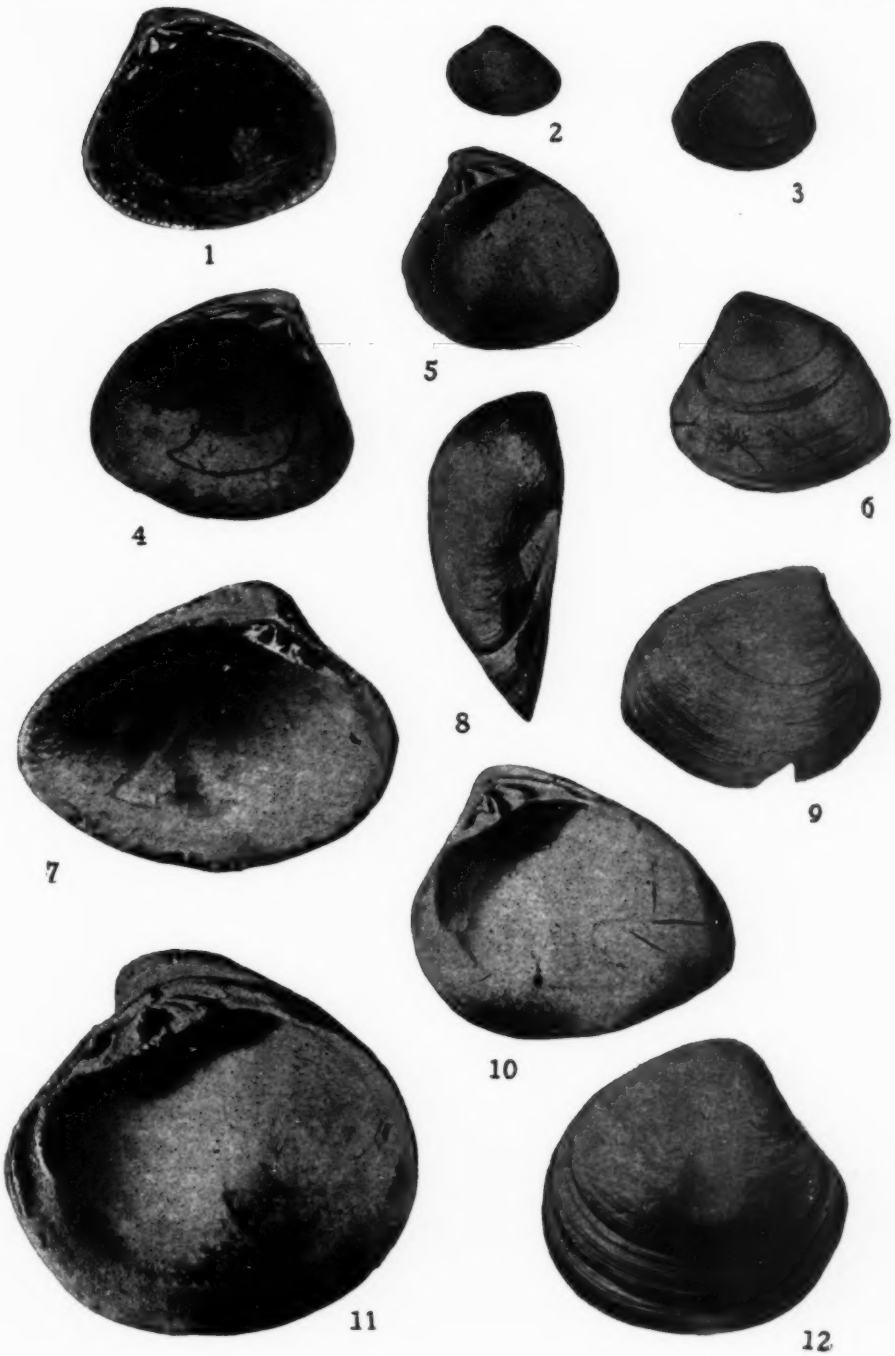
8.—*Pitaria (Pitaria) gazleyensis* Palmer n. sp., holotype; right valve; 33 mm., length; 31 mm., height; 12 mm., semidiameter.

9.—*Pitaria (Rhabdopitaria) pricei* Palmer n. sp., holotype, right valve; 18 mm., length; 15 mm., height; 3.5 mm., semidiameter.

10.—*Pitaria (Rhabdopitaria) pricei* Palmer n. sp., paratype; right valve; 24 mm., length; 20 mm., height; 5 mm., semidiameter; lower margin shows the fine crenulations.

11.—*Pitaria (Pitaria) gazleyensis* Palmer n. sp., holotype.

12.—*Pitaria (Pitaria) gazleyensis* Palmer n. sp., holotype; small area on midsurface ground to see underlying structure.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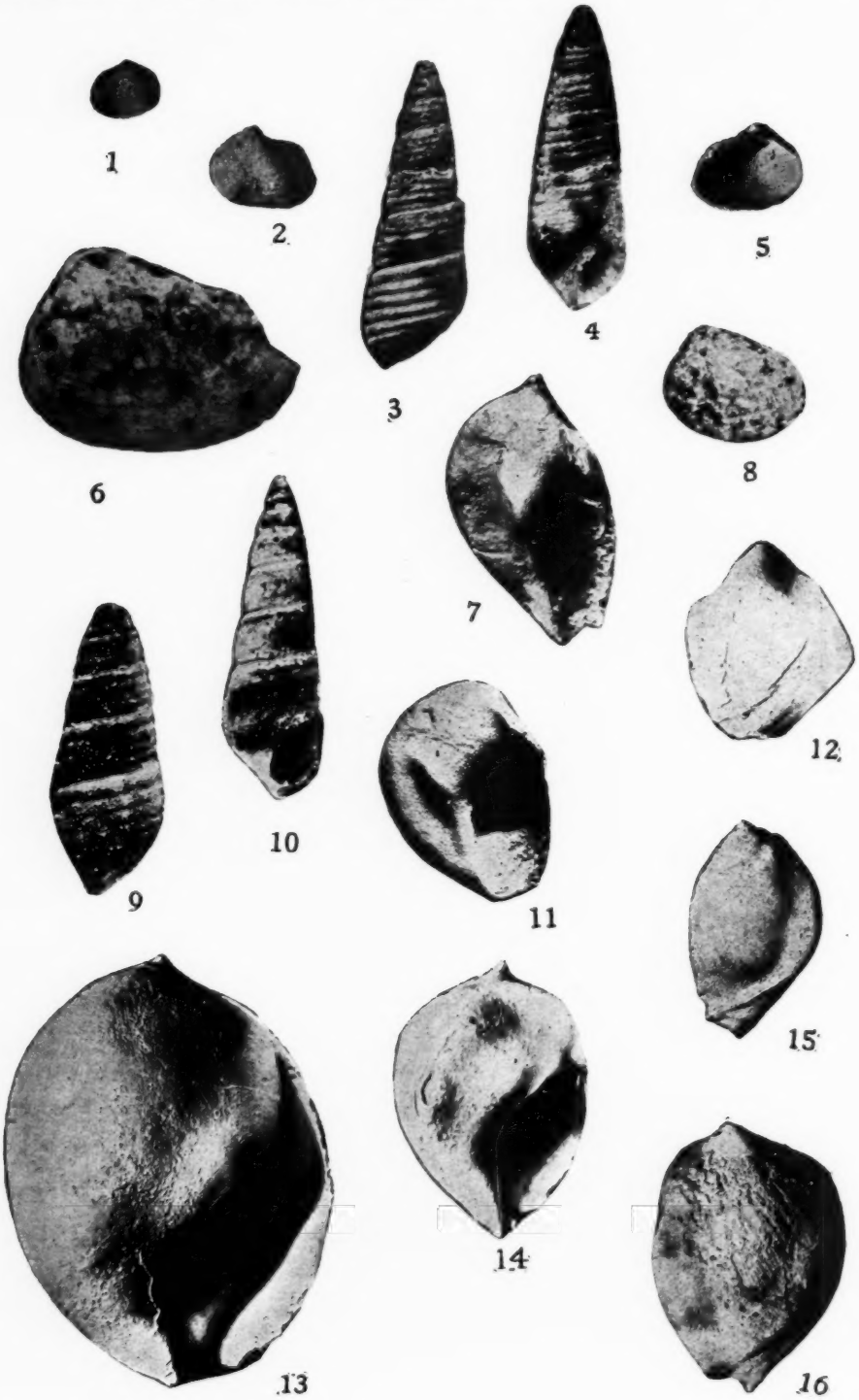
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on the ribs. The concentric ribs on the body whorl are uniform in size and fewer than on *A. elegans*. Lea's[13] figure of *A. elegans* is poor so that we are figuring a shell of the species for comparison.

Dimensions.—7 mm., height; 2 mm., greatest diameter.

[13] Lea, H. C., Amer. Jour. Sci., vol. XL, p. 93, pl. 1, fig. 3, 1841, as Pasithea.

EXPLANATION OF PLATES

PLATE 7

FIG. 1.—*Trinacria adamsi* Palmer n. sp., paratype; right valve; 4 mm., length; 3.5 mm., height; 1 mm., semidiameter.

2.—*Trinacria adamsi* Palmer n. sp., paratype; left valve; 6.5 mm., length; 5 mm., height; 2 mm., semidiameter.

3.—*Acirsa (Acirsella) henryleai* Palmer n. sp., holotype, 7 mm., height; 2 mm., greatest diameter.

4.—*Acirsa (Acirsella) elegans* (H. C. Lea), 7 mm., height; 2 mm., greatest diameter.

5.—*Trinacria adamsi* Palmer n. sp., holotype, left valve; 6.5 mm., length; 5 mm., height; 2 mm., semidiameter.

6.—*Nucula magnifica mauricensis* Harris, left valve; 6 mm., length; 4 mm., height; 1 mm., semidiameter; spotted with iron stains.

7.—*Bullia altile harrisi* Palmer n. var., holotype, 16 mm., height; 11 mm., greatest diameter.

8.—*Nucula magnifica mauricensis* Harris, left valve, 4 mm., length; 3 mm., height; 1 mm., semidiameter; spotted with iron stains.

9.—*Acirsa (Acirsella) henryleai* Palmer n. sp., paratype; 5 mm., height; 2 mm., greatest diameter.

10.—*Acirsa (Acirsella) henryleai* Palmer n. sp., paratype; 7 mm., height; 2 mm., greatest diameter; ribbing eroded, the most common condition in which the specimens are found.

11.—*Bullia altile harrisi* Palmer n. var., paratype; 18 mm., height; 14 mm., greatest diameter.

12.—*Bullia altile harrisi* Palmer n. var., paratype; 20 mm., height; 16 mm., greatest diameter; spire completely enveloped by callus.

13.—*Bullia altile* (Conrad) *(B. subglobosum* [Conrad] form), 40 mm., height; 29 mm., greatest diameter; Gosport sand, Claiborne, Ala.

14.—*Bullia altile* (Conrad), 26 mm., height; 19 mm., greatest diameter; Hatchitigbee, Ala., Sabine Eocene.

15.—*Bullia altile harrisi* Palmer n. var., holotype.

16.—*Bullia altile* (Conrad), same specimen as fig. 14.

SOME ASPECTS OF SEDIMENTARY PETROGRAPHY IN RELATION TO STRATIGRAPHY IN THE BOLIVAR COAST FIELDS OF THE MARACAIBO BASIN, VENEZUELA

HOLLIS D. HEDBERG

ABSTRACT

General results of the petrographic study of sediments are applied to the particular region of the Bolivar Coast oil fields on the eastern shore of Lake Maracaibo, Venezuela. The fundamental differences in the nature of correlations based on different lines of petrographic investigation are shown by the details of such studies in this region.

INTRODUCTION

The sediments of the Bolivar Coast oil fields on the eastern shore of Lake Maracaibo, Venezuela, illustrate rather well some fundamental differences in the nature of correlations based on different lines of petrographic investigation. In order to emphasize these differences it may be worth while to cite certain results of the petrographic study of the sediments, prefaced by a brief discussion of the potential contributions of the several branches of sedimentary petrography. The writer recognizes that this last involves little more than a restatement of principles which, through the work of pioneer investigators, have now become commonplaces of the science, but repetition may serve to make the significance of specific examples more apparent.

The petrographic study upon which this paper is based was carried out under the direction of Dr. J. B. Burnett, chief geologist of the Lago Petroleum Corporation, by courtesy of whom some of the results of particular value for illustration may be made public.

THE SCOPE OF SEDIMENTARY PETROGRAPHY

In its broadest sense sedimentary petrography includes all studies which go to make up a complete description of a sedimentary rock. In oil field work the purpose of this description is usually that of correlation with other sediments. However, mere cataloging and

comparison of descriptive details is not sufficient. Intelligent correlation must be based also on fundamental features bearing on rock genesis—features which become apparent only through interpretation of the more purely descriptive characters. The field of sedimentary petrography may be divided into a number of branches each of which supplies characteristic contributions toward this end.

Lithology includes the descriptive features of the rock as a whole—as an aggregate of minerals or minerals and organic matter—and as such it is an important source of information as to general physical and chemical conditions of deposition. Its scope is almost infinitely broad but the story that it tells is frequently too general and too often repeated to be diagnostic in correlation.

The mineralogy of detrital elements is a criterion of the source of clastic sediments and through its indications of changes in source it becomes a key to regional geologic history. It may also furnish important information as to conditions of weathering, transportation, and deposition.

Authigenic minerals are of paramount value as recorders of environments of deposition and chemical conditions prevailing at and subsequent to the time of deposition.

Paleontology serves to fix the geologic time of origin as well as to throw light on the environment of deposition. Megascopic paleontology stands apart from other branches of the study of sedimentary rocks and is usually considered as a distinct field of investigation. On the other hand micro-paleontology, while strictly falling in the realm of paleontology, is at the same time inevitably bound to the other branches of the microscopic investigation of sediments by practical expedience and methods in technique and consequently may be included as a branch of sedimentary petrography.

The Significance of Lithologic Correlation

Lithologic correlation is essentially true stratigraphic correlation. It divides the geologic column into units of similar lithology, ranging in size from a single thin stratum to a thick series of sediments, and depends in correlation on the lateral persistence of the lithologic character of these beds. A time horizon in a sedimentary series may be defined as the surface of deposition over any area at any particular instant. It is apparent from a consideration of present day conditions that such a time horizon will cut across many different lithologic units. However, in a general way a single stratum will usually parallel time horizons throughout its extent as it was formed in its

entirety within a relatively short period of time. On the other hand two laterally separated but lithologically correlative series of strata may differ considerably in date of formation due to the fact that conditions favorable for the development of the particular lithology in question did not prevail in both places at the same time but shifted gradually from one to the other. Such is the case of the formation which transgresses time divisions when traced from one area to another.

The essential parallelism of lithologic units in a conformable series, regardless of whether or not they parallel time divisions, makes lithologic correlation superior to all others as an aid to the determination of structure and stratigraphic relations over a limited area. This is obvious from the fact that the general attitude of these units is in itself the structure of the series. Stratification is largely a matter of change in lithologic character.

The defects of lithologic correlation lie in the difficulty of application. The lateral variability of lithologic characters and the number of minor factors which can produce apparently profound differences in physical appearance, taken in connection with the usual incompleteness of sections based either on outcrops or well samples, make satisfactory lithologic correlation frequently almost impossible. Where lithology may be tied to major genetic features, such as are furnished by changes in environments of deposition, the difficulty is greatly diminished. Such connection is frequently possible in the case of sediments of chemical or organic origin but with clastic sediments lithology more often merely indicates physical conditions of deposition which may be repeated in substantially the same way so many times in a sedimentary series as to confuse all attempts at correlation based on this feature alone. For long distance correlation lithology is too sensitive to relatively minor and oft repeated changes in physical conditions and too little sensitive to major geologic happenings.

Minerals and fossils are of course frequently characteristic criteria of certain lithologic units and as such may be employed as aids to the identification of these units from place to place. Neither, however, is bound to lithologic boundaries and, without depreciating the value of either in simple lithologic correlation, it is possible that their greatest significance is realized when they are made the bases of independent though mutually complimentary correlations. The ultimate coördination of the several correlations must then take into consideration the fundamental differences between them.

Comparative Significance of Authigenic and Detrital Minerals

Numerous instances of the correlation of sediments by means of detrital mineral content might now be cited. Differences in the mineralogy of detrital elements in certain cases are the results of variations in conditions of weathering, transportation, or deposition, but generally they indicate changes in the source of sediments. As such, in addition to furnishing horizon markers, they are keys to major events in regional geologic history. Uplift, erosion periods, intrusion, extrusion, metamorphism—all leave their impress on the local detrital mineral record.

The boundaries of the mineralogic units thus formed are frequently stratigraphic horizons and for short distances all of them may arbitrarily be so considered. It is obvious, however, that such is not necessarily the case. Where these boundaries are the results of changes in depositional environment, mineral zones are generally speaking stratigraphic units also, but where they are due to differences in source or in conditions of weathering and transportation the two are not necessarily coincident and the former may cut diagonally across the latter.

Authigenic and sedimentary minerals are largely independent of the source of sediments but are frequently delicate indices of the environments of deposition. As such they generally coincide with stratigraphic and lithologic divisions. An exception to this rule may be found in the case of authigenic minerals which reflect post-depositional influences when the distribution of minerals may have been controlled by position with respect to the ground water surface rather than by stratigraphic horizons. Correlation by authigenic minerals is a correlation of environments; correlation by detrital minerals is essentially a correlation of sources.

Comparative Significance of Fossils and Minerals

Correlation by fossils may be either a time or an environmental correlation. Thus far the time correlation has been the principal contribution to petroleum geology. Two separated beds are correlated because they carry the same fossil fauna or flora and thus represent the same time according to the clock of life evolution.

Correlation by detrital minerals is not an absolute time correlation. Contemporaneous deposits with different sources may carry entirely different mineral suites, and beds widely separated in geologic age may still show the same mineral source. Detrital minerals can scarcely be said to know any world-wide epochs or periods. They

are relatively local criteria and tell not absolute time but relative age. They may place a formation not as Eocene or Miocene but as older or younger than certain major events in regional geologic history. For instance, paleontology may show a series of sediments to be of Eocene age. Detrital mineralogy may show the lower half of them to be older than the time of genesis of certain minerals associated with regional uplift and intrusion while the upper half postdates this event.

Neither is correlation of environments, based on authigenic minerals, necessarily a time correlation. For instance, certain authigenic minerals may be characteristic of the near shore phase of sediments deposited by a certain regressing sea. This zone may be traced over a considerable area yet the beds in one place may not be the time equivalents of the beds in another place due to the length of time involved in the retreat. In this case it is perfectly possible that paleontological evidence may show two beds to be of considerably different age whereas their relation to a petroleum source rock is identical. Their absolute age is different but their relative age is the same.

Paleontological correlation has the advantage of the infinite variety of life forms and the controlling feature of progressive and more or less orderly evolutional change. Nevertheless in practice it encounters numerous difficulties. Great thicknesses of strata are barren of fossils; other sediments contain them but in such a poor state of preservation as to render them largely unidentifiable; evolution in one area has progressed more rapidly or differently than in another; variations in life forms due to differences in local environments confuse the interpretation of evolutional change; and so on.

There is no great system such as that of life evolution which governs the arrangement of minerals in the sediments over the earth although it is true that the older rocks carry a much simpler, more stable suite of detritals than those of more recent origin. Furthermore, there are innumerable factors which may produce variation in mineral content and which introduce complexities in the interpretation of mineralogical analyses. On the other hand, difficult though it may be to interpret, the mineralogical record has an advantage in that it is always available. Fossils may be rare or absent but every sedimentary rock carries a record of one side of its history in the detrital and authigenous minerals which it contains.

The use of the various criteria made available by sedimentary petrography involves the recognition and coördination of the several fundamentally different types of correlation. In the development of

the stratigraphy of the Bolivar Coast fields lithologic correlation, time correlation, source correlation, and environmental correlation have all played important parts.

Lithologic Correlation in the Bolivar Coast Fields

Lithologic correlation in the Bolivar Coast fields presents little that is novel or of particular interest for purposes of illustration here. The role of lithology is much the same as in many other fields. Coals, red beds, and tar sands are included in the valuable points of correlation in individual fields. In addition there are certain general features of importance in the interpretation of environment which will be mentioned in a later section in connection with authigenic minerals. In general it may be said that lateral variability and lack of distinctive qualities in clastic sediments make lithology correlation difficult.

Relation of Detrital Minerals to Unconformity

Difficulty in the correlation of the lower part of the well sections in the La Rosa field led to the initiation of a detailed mineralogical investigation of these sediments. The result was the discovery of a rather sharp break in mineralogy just below the base of the producing horizons. Below this break the sediments carry a comparatively simple suite of detrital minerals; above the line there is another and distinctive assemblage of detritals. The principal differences between the two are:

(1) The metamorphic aluminumsilicate minerals, andalusite, kuanite, and sillimanite are found only above.

(2) Staurolite is abundant above and becomes scarce or rare below.

(3) Garnet is rare above but becomes the leading detrital mineral below. Moreover, the garnet of the lower beds frequently has a distinctive dodecahedral structure not found, or at least extremely rare, in the garnet above.

(4) Feldspars (orthoclase, plagioclase, and microcline) are rare above but common below.

(5) Apatite and chloritoid are considerably more common below than above.

The marked difference in content of detritals and the sharpness as well as the completeness of the change at once strongly suggested unconformity. The mineralogical break was then found to coincide with considerable changes in lithology. The same relations were

found to prevail in the neighboring Ambrosio field (four or five kilometers north of La Rosa) and here the line of change showed such marked relief as to indicate beyond question that it represented an old erosion surface. The surface of unconformity has since been extended by means of detrital minerals to the Punta Benitez and Lagunillas fields (10 and 35 kilometers respectively south of La Rosa) and to outcropping formations.

Detrital minerals and lithology made possible the determination of this unconformity while paleontology and authigenic minerals were of little value. The surface marking the break in mineralogy represents not merely a plane of time correlation or of environmental change. It indicates a striking change in source of sediments connected with the genesis of certain thermo-metamorphic minerals or at least their introduction into the sedimentary record and the deletion of certain other species which had hitherto been of common occurrence. The aereal extent and profound nature of the change show its connection with a major event in regional geologic history.

Relation of Authigenic Minerals to Environments of Deposition

Differentiation of the sediments above the unconformity in the northern Bolivar Coast fields by means of detrital minerals is difficult. Lithology is helpful but somewhat undependable. Micropaleontology is applicable only to the fossiliferous section which may be relatively thin or even absent. There are, however, rather marked differences in the character of authigenic and sedimentary minerals in these sediments and a combined study of lithology and authigenic mineralogy makes clear a general sequence of environments in this part of the section which may be correlated from field to field.

The sequence of authigenic and sedimentary minerals, passing upward from the surface of unconformity mentioned in the preceding section, is essentially the same in all fields. A somewhat generalized section would show zones characterized by the following minerals: (a) spherular siderite and a little pyrite; (b) pyrite, nodular phosphate, and nodules of clayey calcium carbonate; (c) glauconite and pyrite; (d) spherular siderite, pyrite, and some nodular phosphate; (e) siderite and ferric oxides; (f) ferric oxides.

The lithology corresponding to these zones is in general as follows: (a) light gray, light green, or whitish clay shales, siltstones, and sandstones, sometimes carrying considerable carbonaceous matter; (b) non-fossiliferous gray and green clay shale and siltstones; (c) gray and green, intermittently fossiliferous claystones and sand-

stones; (d) gray, light green, or whitish non-fossiliferous claystones and siltstones with more or less numerous interbedded lignites; (e) and (f) red, yellow, light gray, or varicolored claystones, siltstones, sandstones, and gravel beds.

Detailed study of the mineralogy and lithology leads to the conclusion that the following sequence of environments corresponds to these zones of sediments: (a) fresh or brackish water deposition in presence of much organic matter under paludal or lacustrine environment, closely associated with definite marine conditions; (b) near shore marine or littoral environment; (c) shallow water marine environment; (d) transition from near shore marine through coal basin environment to definitely continental conditions; (e) fresh water partially reducing environment; (f) fresh water oxidizing environment.

This is an example of correlation of environments of deposition or diagenesis by means of authigenic and sedimentary minerals, used in connection with lithology. It is notable that paleontologic time horizons do not exactly parallel these environmental zones. Also, authigenic minerals do not always necessarily represent depositional environments. For instance, correlation of certain beds in the upper part of the Bolivar Coast section containing siderite spherules almost completely altered to ferric oxide would be a correlation based on weathering, or at least post-dispositional conditions.

Relations of Micro-fossils to Time Divisions

Micro-fossils are present in all four fields of the Bolivar Coast although abundant only in the northern ones. The fossiliferous beds of the Ambrosio section alone have yielded thirty genera and more than seventy species of foraminifera. Deferring any detailed description of the micro-paleontology of the Bolivar Coast sediments, the importance of the role of micro-fossils here may be briefly indicated in order to balance the foregoing discussion.

(1) Miocene age of the fossiliferous section is suggested by micro-fossils alone. Among foraminifera the abundance of *Amphistegina, Miogypsina,* and *Sorites* is significant and the presence of species of *Cupularia, Cupuladria,* and other bryozoa common to beds of Bowden, Gatun, and younger age indicates a faunal development at least equivalent to early Miocene of the West Indies and Panama.

(2) Within the fossiliferous section foraminifera and ostracoda are superior to mineralogic and lithologic markers for local correlation.

(3) The mere presence of certain types of micro-fauna is an important aid in the detailed determination of environments.

Descriptive Mineralogy

The following minerals have been noted in the sediments of the Bolivar Coast fields, above the unconformity to which reference has previously been made:

Fairly common to abundant: andalusite, calcite, chalcedony, chlorite, epidote, glauconite, ilmenite, kyanite, leucoxene, limonite, muscovite, pyrite, quartz, siderite, sillimanite, staurolite, tourmaline, zircon.

Scarce: apatite, chloritoid-ottrelite, corundum, garnet, glaucophane, hornblende, magnetite, orthoclase, rutile.

Rare: undetermined amphibole (?), anatase, barite, biotite, brookite, clino-zoisite, microcline, plagioclase, serpentine, titanite topaz, tremolite.

The principal differences between this assemblage and that below the unconformity have already been noted. As particular emphasis has been given to the mineralogical side of sedimentary petrography it may not be out of place as a matter of record to note a few of the more interesting features of the mineralogy of the Bolivar Coast sediments.

Siderite. This mineral occurs characteristically in small spherules which range from sub-microscopic size to individuals 3 or 4 millimeters in diameter. The color of the spherules varies from a light gray-buff to a deep reddish color depending on the extent of surface alteration to ferric oxides. The structure is both radial and concentric. The siderite forms radiating acicular crystals which are cut by numerous concentric bands marked by color changes. There is no evidence of definite nuclei but included quartz grains are common in all parts of the concretion. The spherules occur typically in light gray, light green, and whitish claystones and siltstones. The boundary against the inclosing rock is sharp and the spherules may be separated readily by washing. Alteration to iron oxides has been more or less effective and in the upper beds has frequently been complete. Some of the slightly altered siderite is distinctly pleochroic. Compound spherules are common.

These siderite spherules are of secondary origin and were probably formed as a product of diagenesis in freshly deposited sediments during periods of fresh or brackish water deposition when much organic matter was accumulating at the surface and waters were heavily charged with carbon dioxide. The carbonic acid waters

brought about reduction and solution of iron bearing minerals with consequent bleaching of sediments to whites and light grays and greens. Subsequent changes in concentration, brought about possibly through compaction of the sediment or changes in temperature or pressure, caused the crystallization of the iron of the solutions in the form of carbonic spherules. Fluctuations in environment during this process are evidenced by the concentric banding of the spherules. The occurrence of the siderite spherules is probably chiefly confined to sediments of fresh or brackish water origin but occasional occurrences in sediments of known marine origin, underlying fresh water deposits, are not surprising if the spherules originated, after the deposition of the sediment, by precipitation from connate or ground waters.[1]

Garnet. The abundant garnet of the sediments below the unconformity frequently shows a very distinctive dodecahedral structure. Many grains of generally irregular shape have the character of cleavage fragments of a mineral possessing excellent dodecahedral cleavage. The plane angles formed by the intersecting cleavages are approximately 70 and 110 degrees; the interfacial angle is in the neighborhood of 60 degrees. Considering the notably poor cleavage of garnet this feature seems worthy of remark as a phenomenon possibly connected with conditions of origin of the mineral during metamorphism. On the other hand certain considerations suggest that this manifestation of crystal structure may possibly not be a true cleavage. (1) Most garnet has notably poor cleavage. (2) These grains, themselves, usually break with the typical subconchoidal fracture of garnet. (3) Associated with the garnets of sharply defined structure are others with pebbled surfaces and all degrees of gradation exist between the rounded surfaces of the pebbled garnet and the sharp angles of the dodecahedral grains. (4) The garnet of the sediments above the unconformity as a rule shows no evidence of this cleavage but is of the usual sub-conchoidal or irregular fracture type. (5) Both the pink and colorless garnets (probably admandine and grossularite) which occur in the sediments below the unconformity show the dodecahedral structure. (6) Pebbled surfaces may be produced on garnet by heating with potassium bisulfate.

The best alternative explanation of the origin of the dodecahedral grain which offers is that it is the result of natural etching by solution. No evidence of secondary growth has been observed.

[1] Spencer has noted that the occurrence of spherulitic siderite in England, Wales, Rhodesia, and India seems without exception to be associated with sediments of fresh water origin. Spencer, E., Occurrences of spherulitic siderite in sediments: Q. J. G. S. LXXXI, p. 684, 1925.

Glauconite. Glauconite occurs as soft black, greenish black, and dark green pellets in association with marine fossils and also in a dark colored, light, porous rock which rarely contains fossils. This latter rock has a micro-oolitic structure due to the abundance of the black and dark green glauconite pellets. The fact that many of the pellets only partially fill rounded cavities in the rock suggests that solution or condensation has occurred subsequent to the time of formation. Glauconite in older outcropping formations of the District of Bolivar is of much lighter green color than that of the well samples.

Pyrite. Pyrite occurs as pyritohedrons, striated cubes, and as spherules and compound spherules, but is most commonly found in minute octahedral crystals. Knowledge of the conditions controlling the manner of crystallization would probably be of considerable value in working out environmental history.

Epidote. Epidotes are not present in great abundance but show considerable variety in appearance. Optical properties range from those of true epidote to those of clinozoisite.

Chloritoid-Ottrelite. A fairly common mineral of the deeper sediments is referred to one or the other of the above mentioned species. Its color by reflected light is greenish gray; by transmitted light it is pleochroic (X: greenish, Y: blue, Z: yellowish green). The refractive index gamma is just below 1.729 and the birefringence is very low. The mineral is biaxial positive and has negative elongation and good basal cleavage.

THE TIME RANGE OF THE FORAMINIFERAN, FLABELLAMMINA ALEXANDERI, IN THE LOWER CRETACEOUS OF NORTH TEXAS

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Through the kindness of Dr. Joseph A. Cushman, the writer had the opportunity of spending several weeks during the fall of 1927, in the Cushman Laboratory for Foraminiferal Research. During that time, Dr. Cushman found, in a sample collected by the writer from the Goodland formation of the Lower Cretaceous of North Texas, a new and interesting genus of the Foraminifera, which has recently been described, with a single specific representative, in the Contributions from the Cushman Laboratory for Foraminiferal Research.[1]

Dr. Cushman, in his paper, describes only a single locality, but since this form has proved to be an excellent horizon-marker, and since the writer has made a fairly representative collection of samples from the clays and marls of the Lower Cretaceous formations of North Texas, Dr. Cushman has suggested that a brief paper be prepared, describing the known stratigraphic and areal distributions of the new genus.

In order to determine the time-range of this genus, and its distribution in northern Texas, the writer studied samples from numerous surface exposures of the various Lower Cretaceous formations, throughout their broad belt of outcrop in northern Texas, bounded roughly by the Red river on the north, and the Brazos river on the south, and also a great number of samples from a series of cores from several wells drilled through the Lower Cretaceous formations in Tarrant County by the Tarrant County Water Improvement District No. 1.

Examples of this genus were found only in samples from the upper one-third of the Goodland formation, and from one exposure of the uppermost part of the Kiamitia formation on Mustang Creek in northern Johnson County.

[1] Cushman, Joseph A., Contr. Cushman Lab. Foram. Res., vol. 4, 1928, p. 1, pl. 1, figs. 3, 4.

The genus is most abundant at about the middle of its stratigraphic range, being less common toward the upper and lower limits.

Every sample of marl from the upper one-third of the Goodland formation in any part of North Texas that the writer has studied, has contained specimens of this genus.

Because some of the readers of this note may not have easy access to Dr. Cushman's original description of the genus and its single species, a brief characterization is added here.

Fig. 1

Fig. 2

Genus FLABELLAMMINA Cushman

FLABELLAMMINA ALEXANDERI Cushman

Figures 1, 2

Test compressed, leaf-like; early chambers planospiral, later chambers uniserial, extending back on the two sides of the test, forming inverted V-shaped chambers; division into chambers obscure externally; aperture simple, terminal; wall of test coarsely arenaceous.

Figures, 37X.

A REVISION OF THE FAMILY ORBITOIDIDAE

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ABSTRACT

The family Orbitoididae embrace the discoidal Foraminifera which are composed of a median zone of chambers and two lateral zones of chambers or laminae. The genera consist of three well-marked groups: (1) with lateral laminae and rectangular median chambers, the subfamily Cycloclypeinae; (2) with lateral chambers and rectangular median chambers, the subfamily Discocyclininae; and (3) with lateral chambers and arcuate, spatulate, ogival, rhombic or hexagonal median chambers, the subfamily Orbitoidinae. The family has evolved from the Camerinidae.

INTRODUCTION

The Orbitoididae are characterized by having a large, discoidal test, consisting of a median (or equatorial) zone of chambers which is covered on both sides by layers of laminae without chamber cavities, or by layers of chambers in tiers. The wall is calcareous and imperforate, except for a vestigial canal system in the walls of the median chambers and perforations in the walls of the lateral laminae and chambers. The lateral layers of laminae or chambers do not correspond exactly in number with the number of whorls or annulae of chambers of the median zone, which distinguishes the Orbitoididae from the Camerinidae, in which the chambers are equitant.

The Orbitoididae or orbitoids have been very extensively studied, and although specimens have been known and species named long before the first genus, *Orbitoides*, was named by d'Orbigny in 1848, the study of the structure and relationships of the orbitoids was begun by Carpenter in 1850 (Quart. Jour. Geol. Soc. London, vol. 6, 1850, p. 32). Some 400 papers have been written on the orbitoids (bibliography by Silvestri, Mem. Pont. Accad. Rom. Nuovi Lincei, vol. 29, 1911, pp. 56-77).

Notwithstanding the large amount of work which has been done on the group, their structure, the relative significance of the different

structures on classification, the classification, phylogeny and ancestry, are still very imperfectly known.

The present paper is an attempt to bring together all the generic names which have been proposed for the orbitoids, to assemble the significant facts about the genera, and to help toward the classification and determination of the phylogeny of the group.

The Orbitoididae are the largest, most complex and highly evolved of the Foraminifera. They were the giants among the Foraminifera, and like all giant races, including the Camerinidae and the Fusulinidae, they were short lived in geologic time, and are therefore among the best of index fossils. The orbitoids are found first in the Upper Cretaceous, occur commonly in the Eocene, reached their acme in the Oligocene, became less common in the Miocene, very rare in the Pliocene, and a few species survive to the Recent.

Nomenclature and Synonomy

There have been proposed forty-two names for the genera of Orbitoididae, of which twenty-four may be recognized as distinct and valid, and eighteen as synonyms or invalid names. In this study the Rules of Nomenclature have been followed for families and subfamilies, as well as for genera and species, and I have studied the original descriptions of all the genera, valid and invalid, and of nearly all the genotypes, and a large number of specimens representing many of the genera. But I make no claim to finality. The facts as they are accumulated must speak for themselves.

Only one important change is made in nomenclature, which is the recognition of *Cyclosiphon* Ehrenberg, 1855, in place of the more commonly used name *Lepidocyclina* Gümbel, 1870. The name *Cyclosiphon* was properly proposed, described, and the single species *Nummulites mantelli* Morton named. *Lepidocyclina* has the same type species.

In the systematic part of this paper I have given the type species of each genus, the original reference, the age of the rocks from which it came and the locality. In the synonymy of each genus, I have given for forms not identical with the genotype, the supposed distinguishing character. The references include the most significant ones for each genus.

Classification

The Orbitoididae have usually been classified as a subfamily, the Cycloclypeinae, in the Camerinidae (formerly Nummulitidae).

While the structural similarities between the Camerinidae and the Orbitoididae are sufficient to show the close relationship of the two groups, the difference between the one layer of equitant chambers of the Camerinidae and the three layers of chambers of the Orbitoididae are sufficient to make convenient groups which are easily recognizable. The differences are expressed in the common names "orbitoids" and "nummulites."

There are two well-marked groups in the Orbitoididae: (1) forms with annular or nearly annular chambers which are divided by secondary septa into quadrangular chamberlets, embracing the Cycloclypeinae and the Discocyclininae, and (2) forms with arcuate chambers, or some modification of an arc in shape, in which the chambers are not divided into chamberlets, the Orbitoidinae. The Cycloclypeinae and Discocyclininae have much finer structure than the Orbitoidinae have, and show great structural similarities to *Heterostegina,* from which they were undoubtedly derived. The Orbitoidinae are more similar to *Camerina* and *Arnaudiella,* through which they have been derived.

It would therefore be proper to have two families for the two groups, but for convenience, both groups are here included in the one family.

The first group, in which the chamberlets are quadrangular, is divided into two subfamilies: (1) forms with lateral laminae without chamber cavities, the Cycloclypeinae, and (2) forms with layers or tiers of lateral chambers, the Discocyclininae. The forms with arcuate or modified arcuate median chambers and layers or tiers of lateral chambers form the third subfamily, the Orbitoidinae, or typical orbitoids. Further study may show that the Cycloclypeinae and the Discocyclininae constitute a single subfamily or family, and that the distinction between lateral laminae and lateral chambers is without even generic importance.

Structure and Phylogeny

Cycloclypeinae.—The walls of the median chambers consist of three layers, an outer, an inner and a median layer with canal system. There are foramina between the chamberlets of two adjacent annuli, but not between adjacent chamberlets in the same annulus. The wall is otherwise imperforate. The lateral laminae are perforate and have pillars, and nearly correspond in number with the number of annular chambers, which fact shows that the Cycloclypeinae were derived from a form with equitant chambers.

The structure of the Cycloclypeinae corresponds in nearly all respects with that of *Heterostegina*, as determined by Carpenter (Introduction, 1862, p. 297), differing in having annular chambers and in having lateral laminae. It seems established that *Heterostegina* was the ancestor of the Cycloclypeinae.

Heteroclypeus is little more than a *Heterostegina* in which the alar prolongations of the chamber walls are laid down as solid laminae. The spiral form is retained until the adult stage is reached, when the chambers become annular.

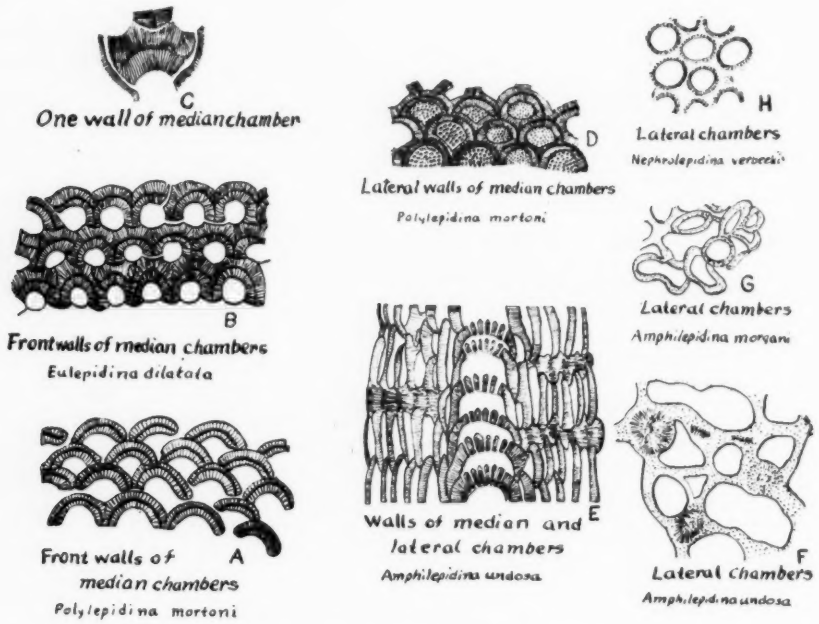


Fig. 1. Wall structure of Orbitoidinae.

Cycloclypeus evolved from *Heteroclypeus* by nearly or completely accelerating out the spiral, ancestral stage. *Orbitoclypeus* evolved from *Cycloclypeus* by a zigzagging of the chamber walls, producing subhexagonal chamberlets in parts of the median zone. *Pseudophragmina*, which is often identified with *Discocyclina*, was derived from *Cycloclypeus* by ceasing to form complete secondary septa and walls, the septa and walls appearing as lines of granules.

Discocyclininae.—The wall structure of this subfamily is the same as that of the Cycloclypeinae. *Spiroclypeus* is little removed from its ancestor, *Heterostegina*, differing only in having lateral zones of

chambers and the beginning of the differentiation of the median zone from the lateral zone of chambers. *Discocyclina* was derived from *Spiroclypeus* by acceleration, the coiled ancestry being still indicated in the microspheric form. In *Rhipidocyclina* the median chamberlets have been again divided by tertiary septa, parallel to the median zone, into smaller chamberlets. In *Actinocyclina* numerous radial lines of chambers are larger than the average, making raised rays on the surface. In *Asterocyclina* a few prominent rays are developed. *Actinocyclina* and *Asterocyclina* are scarcely more than subgenera of *Discocyclina,* but because of the ease of distinguishing the three groups they are here retained as genera.

Orbitoidinae.—The three zones of chambers and the shapes of the median chambers are the characteristic features of the Orbitoidinae. The front walls of median chambers are imperforate, and consist of three layers, an outer and an inner, light-colored layer composed of fibers at right angles to the third layer, a dark, granular, median layer, which is probably a vestigial, mural canal system. (Fig. 1, *a, b, c.*) The side walls of the median chambers are perforate, and consist of a single, light-colored layer. (Fig. 1, *e.*)

The median chambers are arcuate in the earlier or Cretaceous species and in the earlier stages of later species. Foramina at either side of the base of the front wall connect adjacent chambers of the same annulus and chambers of adjacent annuli. (Fig. 1, *a-e.*)

The arcuate chamber is a true chamber, not a chamberlet, and is derived from the simple chamber of a coiled form, as seen in *Camerina* and many other genera of coiled Foraminifera (Fig. 2, Microspheric nucleoconch). The arcuate form developed into the open arcuate and tangentially rhombic forms by radial compression; into the ogival and radially rhombic forms by compression at 45° from the radius; into the spatulate form by compression tangentially to the periphery of the test; and into hexagonal forms by compression in every direction. The shape of the median chamber is determined by the dark, median layer. The various forms of median chambers are the most reliable criteria for recognition of the different genera in the microspheric generation. The various forms and their derivation are shown in Fig. 2.

The lateral chambers, in parallel sections, vary greatly in shape in the different species and different parts of the same specimen, and are of little value in generic identification. Precisely the same shapes of vacuities or chamberlets may be seen in various species of *Camerina* (d'Archiac and Haime, Anim. Foss. de l'Inde, 1853, pls. 3, 4). Three of the many forms are shown in Fig. 1, *f, g, h.*

The microspheric nucleoconch is planispiral in all of the genera of Orbitoidinae in which it has been observed, and the different genera cannot be distinguished by that character (Fig. 3), but microspheric forms are identified by the shapes of the median chambers and specific identity with megaspheric specimens.

The megaspheric nucleoconchs vary much in structure, and it is on them that most of the genera of Orbitoidinae have been erected. The various forms of nucleoconchs and the median chambers of the different genera are shown in Fig. 3.

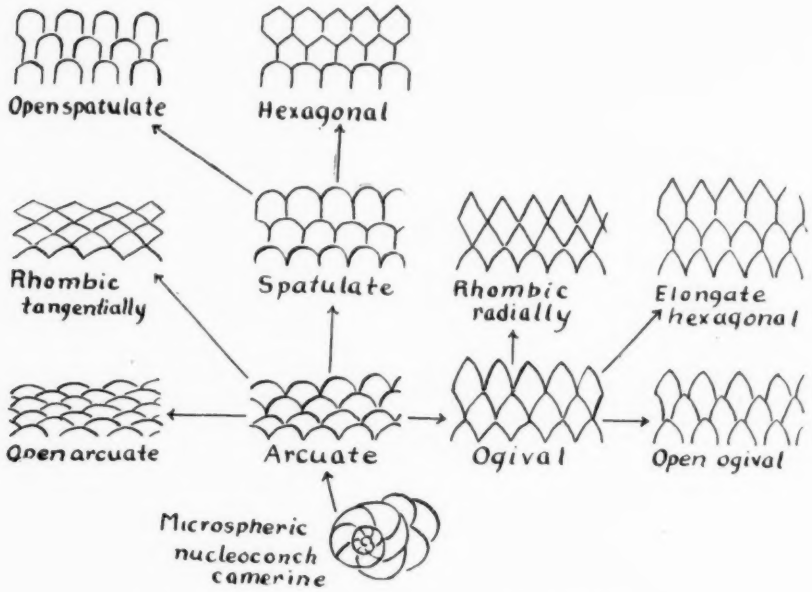


Fig. 2. Shapes of median chambers of Orbitoidinae.

It cannot be maintained that evolution of the Orbitoidinae has taken place in general through the megaspheric form. Hence, the phylogeny of the group is determined by the shapes of the median chambers and the positions in the geologic column.

The Orbitoidinae have evolved from the Camerinidae, as is shown by the great correspondence in the structure of the two groups: the planispirally coiled, involute nucleoconch, the wall structure with the three layers and canal system, the lateral chambers, the pillars, and the equitant whorls of *Helicolepidina*. The ancestral form of the Orbitoidinae is the genus *Arnaudiella* (Douvillé, Bull. Soc. Géol. France, ser. 4, vol. 6, 1906, p. 599), which is almost perfectly inter-

mediate between *Camerina* and *Helicolepidina*. Silvestri has noted (Atti Pont. Accad. Rom. Nuovi Lincei, vol. 76, 1923, p. 6), the similarity between the shape of the chambers of *Planorbulina* and those of the Orbitoidinae. But there is only one layer to the wall of *Planorbulina*, there are no lateral chambers or pillars, the genus is attached and degenerate, and is unknown before the Tertiary. It is fairly evident that such a form could not give rise to a Cretaceous form of higher and different structure.

Helicolepidina, so far found in rocks identified as Eocene, is the

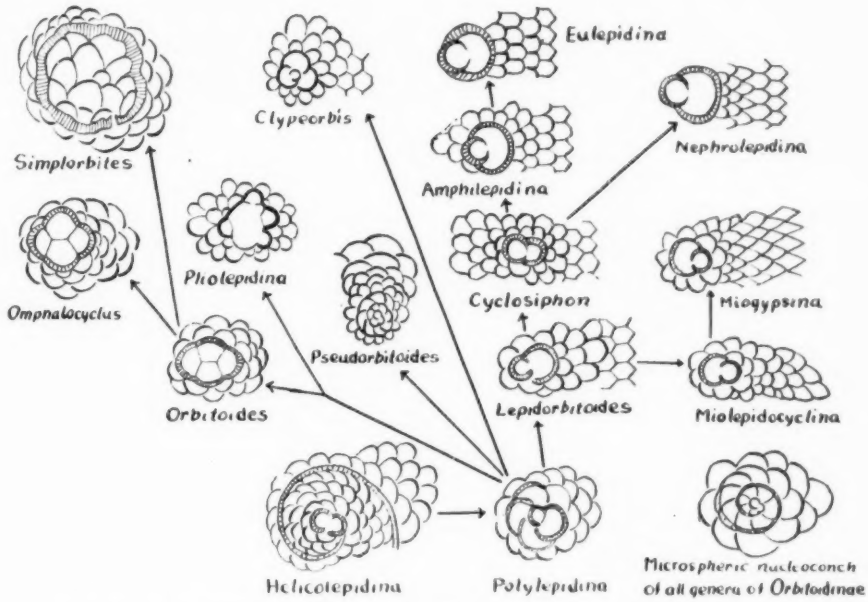


Fig. 3. Nucleoconchs, median chambers and phylogeny of Orbitoidinae.

most primitive genus of Orbitoidinae. It has many of the characters of *Camerina* and especially of *Arnaudiella*, including the involute whorls, and it shows how the three zones of chambers of the orbitoids were formed, by separation of the equitant chamber into three parts. *Helicolepidina* should also occur in the Cretaceous.

Polylepidina is the earliest form known, occurring in the Cretaceous, and it has a coiled nucleoconch and arcuate median chambers in both microspheric and megaspheric generations.

All of the remaining genera of Orbitoidinae have evolved, directly or indirectly from *Polylepidina*, in some such way as shown in Fig. 3.

It is probable that far too many genera of the family Orbitoididae

are still recognized, and while the tendency during the last twenty years has been to make more and more genera for intermediate stages, the reaction is sure to come with better understanding of the relationships of genera. The Orbitoididae could be combined into ten or twelve genera with no loss in precision of definition or understanding of phylogeny, or disadvantage in stratigraphy, and considerable gain in saving of time in puzzling over distinctions of little significance.

Fig. 4 shows my present conception of the classification and phylogeny of the family.

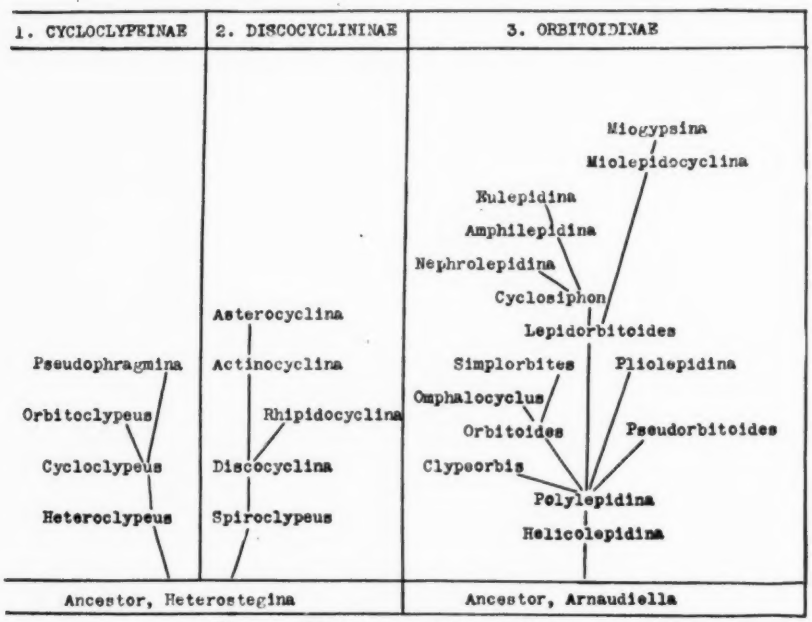


Fig. 4. Phylogeny of the Orbitoidae.

SYSTEMATIC PART

Family ORBITOIDIDAE Schubert, 1920

Family Orbitoididae SCHUBERT, Pal. Zeitschr., vol. 3, pt. 2, 1920, p. 157.

Tests free, discoidal, flat or sellaeform, with a planispiral or rarely trochoid nucleoconch in the microspheric form, and a larger, coiled or non-coiled nucleoconch made up of several chambers, variously arranged, in the megaspheric form; test consisting of a median or equatorial zone of rectangular, arcuate, spatulate, ogival, rhombic or

hexagonal chambers, arranged spirally, annularly or in intersecting curves, and lateral zones of laminae or of chambers in layers and tiers, with or without pillars; walls and septa calcareous, thick, the lateral walls perforate, with or without mural canal system; surface smooth or variously ornamented; apertures, many pores on the periphery. Diameter, 1 to 80 mm. The megaspheric form (A) is much more abundant but smaller than the microspheric form (B).—Warm, shallow water.—Upper Cretaceous to Recent.

KEY TO SUBFAMILIES

Lateral zones of laminae ..... *Cycloclypeinae*
Lateral zones of chambers
  Median chamberlets rectangular ..... *Discocyclininae*
  Median chambers arcuate, ogival, rhombic, spatulate or hexagonal ..... *Orbitoidinae*

Subfamily 1. CYCLOCLYPEINAE Bütschli, 1880

Subfamily Cycloclypeinae BÜTSCHLI, in BRONN'S Kl. Ordn. Thier-Reichs, vol. 1, 1880, p. 215.

Test discoidal, consisting of a median zone of chambers which is covered on each side by a zone of closely appressed laminae; median chambers planispiral in the young and annular in the adult, or entirely annular, and divided into rectangular chamberlets; walls calcareous, thick, with mural canal system; apertures consist of rows of pores on the periphery. Diameter, 2 to 63 mm.—Shallow, warm water.—Eocene to Recent.

KEY TO GENERA

Radial septa complete
  Chambers mostly spiral ..... *Heteroclypeus*
  Chambers annular
    Chamberlets rectangular ..... *Cycloclypeus*
    Chamberlets partly hexagonal ..... *Orbitoclypeus*
Radial septa incomplete ..... *Pseudophragmina*

Genus HETEROCLYPEUS Schubert, 1906

Genoholotype *Heteroclypeus cycloclypeus* (SILVESTRI) = *Heterostegina cycloclypeus* SILVESTRI, Atti Pont. Accad. Rom. Nuovi Lincei, vol. 58, 1905, p. 126. Not figured. (Oligocene, Anghiari, Italy.)

Heteroclypeus SCHUBERT, Centralbl. Min. Geol. Pal., 1906, p. 640; Neues Jahrb., Beil.-Bd. 25, 1908, p. 259.—YABE and HANZAWA, Sci. Rep. Tohoku Imp. Univ., Sendai, Japan, ser. 2, Geol., vol. 7, no. 4, 1925, p. 102, pl. 25, figs. 1, 3-5.

Test discoidal, consisting of a median zone of chambers with a laminated zone on each side; chambers planispirally arranged in early and middle stages and annularly in adult stages, the chambers divided into rectangular chamberlets; wall calcareous, probably with mural canal system; lateral walls finely perforate.—Oligocene and Miocene.

This genus is intermediate between *Heterostegina* and *Cycloclypeus*. It may be the microspheric form of *Cycloclypeus*. It has not been adequately figured.

Genus CYCLOCLYPEUS Carpenter, 1856

CARPENTER, Phil. Trans. Roy. Soc. London, vol. 146, 1856, p. 555, pl. 29, figs. 10-12; pl. 30, figs. 1-4; pl. 31, figs. 2-6, 8-10, described and figured, no species named; Introd. Foram., 1862, p. 292.

Genotype (CARPENTER'S specimens, under Rules of Nomenclature, Art. 2, Opinion 46) *Cycloclypeus carpenteri* BRADY, Rep. Voy. *Challenger*, Zool., vol. 9, 1884, p. 752. (Recent, off Borneo.)—MARTIN, Niederländ. Arch. Zool., vol. 5, pt. 2, 1880, p. 185.—YABE and HANZAWA, Sci. Rep. Tohoku Imp. Univ., Sendai, Japan, ser. 2, Geol., vol. 7, no. 2, 1925, p. 55.

Test free, compressed discoidal, thickest at the center, composed of a planispiral nucleoconch in the microspheric form and of two or three unequal chambers in the megaspheric form, surrounded by annular chambers which are divided into rectangular chamberlets; the equatorial disk of chambers is covered by laminated, lateral plates, especially near the center, in which are vertical, solid pillars; wall calcareous, thick, with labyrinthic canal system; surface smooth or pustulose, especially at the center; aperture a row of pores on the periphery. Diameter, 5 to 63 mm.—Eocene to Recent.

Genus ORBITOCLYPEUS Silvestri, 1907

Genoholotype *Orbitoclypeus himerensis* SILVESTRI, Atti Pont. Accad. Rom. Nuovi Lincei, vol. 60, 1907, p. 106, not figured, (Upper Eocene, Termini-Imerese, Palermo, Sicily); ibid., p. 177; Boll. Soc. Geol. Italy, vol. 26, 1907, p. 59; ibid., vol. 42, for 1923, 1924, p. 29, pl. 1, fig. 14, *O. tellini* SILVESTRI; fig. 17, *O. orbitoideus* (DOUVILLÉ); Mem. Pont. Accad. Rom. Nuovi Lincei, vol. 28, 1910, pp. 119, 132.—VAUGHAN, Bull. Geol. Soc. Am., vol. 35, no. 4, 1924, p. 813.

Exagonocyclina CHECCHIA-RISPOLI, Giorn. Sci. Nat. Econ. Palermo, vol. 26, for 1908, 1909, pp. 159, 187; ibid., vol. 27, 1909, p. 104, figs. 22, 23. Genotype (first species, here designated) *Orbitoides (Exagonocyclina) schopeni* CHECCHIA-RISPOLI, (Eocene, Palermo, Sicily) = *Orbitoclypeus himerensis* SILVESTRI.

Test discoidal, consisting of a thin, median zone of chambers between lateral zones of laminae (chambers?); microspheric

nucleoconch planispiral; megaspheric nucleoconch bilocular, the proloculum nearly or completely embraced by a second, larger chamber; median chambers divided into chamberlets which are radially elongate, frequently alternating with those of the previous chamber, and tend to become hexagonal by the zigzagging of the annular wall; surface nearly smooth; apertures unknown. Diameter, up to 2 mm. —Upper Eocene of Sicily, Umbria, and Mexico (?).

Genus PSEUDOPHRAGMINA Douvillé, 1923

Genoholotype *Pseudophragmina floridana* (CUSHMAN) = *Orthophragmina floridana* CUSHMAN, U. S. Geol. Surv. Prof. Pap. 108-G, 1917, p. 116, pl. 40, fig. 3; Prof. Pap. 125-D, 1920, p. 44, pl. 9, fig. 7. (Upper Eocene, Ocala limestone, near Marianna, Florida.)

Pseudophragmina DOUVILLÉ, Com. Ren. Somm. Séan. Soc. Géol. France, May 28, 1923, p. 106; Bull. Soc. Géol. France, ser. 4, vol. 23, 1923, p. 373, pl. 13, figs. 1-3.—VAUGHAN, Bull. Geol. Soc. Am., vol. 35, 1924, p. 791.

Test discoidal, flat or undulating; surface papillate in concentric lines; test consisting of an equatorial zone of annular chambers which are divided into radially elongate, rectangular chamberlets by thin, granulous, incomplete septa, and two lateral, laminated zones which are transversed by tenuous pillars and minute pores; the megaspheric nucleoconch consists of a globular proloculum partially embraced by a larger chamber and sometimes followed by a third large chamber; microspheric form unknown; special apertures absent. Diameter, 2 to 14 mm.—Upper Eocene, Florida and California, and Chaipas, Mexico.

Pseudophragmina is more like *Cycloclypeus* than it is like *Discocyclina*, since there are no lateral chambers but only closely appressed laminae. It differs from *Cycloclypeus* in the granulose and incomplete secondary septa and in finer structure. Other species are *Orthophragmina flintensis* Cushman and probably *O. clarki* Cushman.

Subfamily 2. DISCOCYCLININAE new subfamily

Test free, discoidal, consisting of a median or equatorial zone of spiral or annular chambers which are divided into rectangular chamberlets, and a lateral zone of chamberlets on each side of the median zone, with or without pillars; microspheric nucleoconch planispiral; megaspheric nucleoconch bilocular, the second, larger chamber partially or completely embracing the first; wall calcareous, with vestigial, mural canal system, those of lateral chambers finely

perforate. Diameter, up to 50 mm.—Shallow water sediments.—Latest Cretaceous, Eocene to Miocene, mostly upper Eocene.

KEY TO GENERA

Surface without raised rays
- Chambers spiral ..... *Spiroclypeus*
- Chambers annular
  - Median chamberlets not divided ..... *Discocyclina*
  - Median chamberlets divided ..... *Rhipidocyclina*

Surface with raised rays
- Rays 3 to 6 ..... *Asterocyclina*
- Rays 8 to 32 ..... *Actinocyclina*

Genus SPIROCLYPEUS Douvillé, 1905

Genoholotype *Spiroclypeus orbitoideus* DOUVILLÉ, Bull. Soc. Géol. France, ser. 4, vol. 5, 1905, p. 459, pl. 14, figs. 1-6. (Upper Oligocene, near Tandjong, Borneo.)—BOUSSAC, Bull. Soc. Géol. France, ser. 4, vol. 6, 1906, p. 93.—YABE, Sci. Rep. Tohoku Imp. Univ., Sendai, Japan, ser. 2, Geol., vol. 5, 1918, p. 48.—VAN DER VLERK, Verh. geol. Mijnb. Gen. Nederland Kol., Geol. Ser., vol. 8, 1925, p. 561.—YABE and HANZAWA, ibid., p. 617.—NUTTALL, Quart. Jour. Geol. Soc. London, vol. 82, pt. 1, 1926, p. 36.

Test discoidal with central bosses, consisting of an equatorial, spiral zone of chambers and rectangular chamberlets, as in *Heterostegina,* on each side of which is a zone of rectangular chamberlets, with or without pillars; microspheric nucleoconch planispiral; megaspheric nucleoconch bilocular, consisting of a globular proloculum which is partially embraced by a second, larger chamber; lateral chambers in tiers, each tier corresponding to a median chamberlet; walls calcareous, those of the median chambers with vestigial canal system, those of lateral chambers finely perforate. Diameter, up to 40 mm.—Upper Eocene, Oligocene and Lower Miocene, Italy, Philippines and East Indies.

Genus DISCOCYCLINA Gümbel, 1870

Genotype (first species, here designated) *Discocyclina pratti* (MICHELIN) = *Orbitulites Pratti* MICHELIN, Icon. Zoöphytol., 1846, p. 278, pl. 63, fig. 14, (Upper Eocene, Biarritz, France) = *Orbitoides (Discocyclina) papyracea* GÜMBEL, 1870, (not *Nummulites papyracea* BOUBEE, 1832, which is *Simplorbites*).

Discocyclina GÜMBEL, Abh. k. bay. Ak. Wiss. München, Math.—Phys. Cl., for 1868, 1870, pp. 687, 690, pl. 3, figs. 3-11, 19-29.—DOUVILLÉ, Bull. Soc. Géol. France, ser. 4, vol. 22, 1922, pp. 55, 85.—VAUGHAN, Bull. Geol. Soc. Am., vol. 35, 1924, p. 789.

Orthophragmina MUNIER-CHALMAS, Étude du Tithonique, etc., Paris, 1891, p. 18; genotype (designated by SCHLUMBERGER, 1901) *Orbitulites Pratti*

MICHELIN, 1846=*Orbitolites fortisi* D'ARCHIAC, 1850, mentioned by MUNIER-CHALMAS; *Orthophragmina* is therefore a typonym of *Discocyclina*.—SCHLUMBERGER, Bull. Soc. Géol. France, ser. 4, vol. 1, 1901, p. 464; ser. 4, vol. 3, 1903, p. 274.—CUSHMAN (part), U. S. Geol. Surv. Prof. Pap. 108-G, 1917, p. 115; Prof. Pap. 125-D, 1920, p. 39.

Nodocyclina HEIM, Abh. Schweiz. pal. Gesell., vol. 35, 1908, pt. 4, p. 271, figs. 25, 26; genotype (here designated) *Orthophragmina umbilicata* DEPRAT, Bull. Soc. Géol. France, ser. 4, vol. 5, 1905, p. 497, pl. 16, figs. 2-11. (Thicker at the periphery than at the center.)

? *Lycophris* MONTFORT, Conch. Syst., vol. 1, 1808, p. 159, and *Egeon* MONTFORT, ibid., p. 167, are possibly this genus, but are unrecognizable.

Test discoidal, consisting of a median zone of annular chambers divided into rectangular chamberlets, and lateral zones of chamberlets, with or without pillars; microspheric nucleoconch planispiral; megaspheric nucleoconch bilocular, consisting of a globular chamber partially surrounded by a larger chamber; wall calcareous, with vestigial, mural canal system, those of lateral chamberlets finely perforate; surface smooth, papillate, pitted or reticulate, but without radial ridges. Diameter, up to 50 mm.—Latest Cretaceous (Danian) and Eocene.

Genus DISCOCYCLINA

Subgenus DISCOCYCLINA Gümbel, 1870

Median zone of chamberlets not divided into smaller chamberlets by partitions parallel to the median zone.—Latest Cretaceous (teste Douvillé) and Eocene.

Genus DISCOCYCLINA

Subgenus RHIPIDOCYCLINA Gümbel, 1870

Genotype (first species, here designated) *Discocyclina (Rhipidocyclina) nummulitica* (GÜMBEL)=*Hymenocyclus* (?) *nummuliticus* GÜMBEL, Geogn. Besch. Bayern, vol. 1, 1861, p. 653. (Upper Eocene, Bavarian Alps.)

Rhipidocyclina GÜMBEL, Abh. k. bay. Ak. Wiss. München, Math.-Phys. Cl., for 1868, 1870, pp. 688, 702, pl. 4, figs. 1-3, 16-18.—DOUVILLÉ, Bull. Soc. Géol. France, ser. 4, vol. 22, 1922, pp. 73, 91.

Like *Discocyclina, sensu stricto,* except that the median chamberlets are divided into smaller chamberlets by partitions parallel to the median zone.—Eocene.

Genus ACTINOCYCLINA Gümbel, 1870

Genotype (first species, here designated) *Actinocyclina radians* (D'ARCHIAC)=*Orbitolites radians* D'ARCHIAC, Mém. Soc. Géol. France, ser. 2, vol. 3, 1848, p. 405, pl. 8, fig. 15. (Upper Eocene, Biarritz, France.)

Aktinocyclina GÜMBEL, Abh. k. bay. Ak. Wiss. München, Math.-Phys. Cl., for

1868, 1870, pp. 688, 707. The correct transliteration from the Greek is *Actinocyclina*, so spelled by GÜMBEL, p. 707.

Actinocyclina GÜMBEL, ibid., p. 707.—DOUVILLÉ, Bull. Soc. Géol. France, ser. 4, vol. 22, 1922, pp. 79, 95, pl. 5, fig. 6. Type of the species, refigured.

Orthophragmina (part) SCHLUMBERGER, Bull. Soc. Géol. France, ser. 4, vol. 1, 1901, p. 120.—CUSHMAN, U. S. Geol. Surv. Prof. Pap. 108-G, 1917, p. 115; Prof. Pap. 125-D, 1920, p. 39.

Asteriacites SCHLOTHEIM, Nachträge Petrefaktenkunde, 1822, p. 71, pl. 12, fig. 6; a homonym of *Asteriacites* SCHLOTHEIM, 1820, an asteroid.—*Asteriacites* (part) VAUGHAN, Bull. Geol. Soc. Am., vol. 35, 1924, p. 790.

Test discoidal, with 8 to 32 radial rays which extend slightly if at all beyond the general periphery; otherwise like *Asterocyclina*.—Lower, Middle and Upper Eocene of Europe, Upper Eocene of America.

Genus ASTEROCYCLINA Gümbel, 1870

Genotype (monotypic) *Asterocyclina pentagonalis* (SCHAFHÄUTL) = *Asterodiscus pentagonalis* SCHAFHÄUTL, Sud-Bayerns Lethaea Geog., 1863, p. 107, pl. 15, fig. 2. (Eocene, near Bergen, southeast Bavaria.)

(*Asteriatites* SCHLOTHEIM, Leonard's Taschenbuch ges. min., vol. 7, 1813, p. 68, a comatulid crinoid.)

(*Asteriacites* SCHLOTHEIM, Die Petrefactenkunde, 1820, p. 324, pl. 29, fig. 6, an asteroid.)

Asterodiscus EHRENBERG, Abh. k. Ak. Wiss. Berlin, Phys.-Math. Cl., for 1838, 1840, pp. 123, 130; unrecognizable, possibly a bryozoan.

Asterodiscus SCHAFHÄUTL, Sud-Bayerns Lethaea Geog., 1863, p. 107; a homonym of *Asterodiscus* EHRENBERG, 1840.—DOUVILLÉ, Bull. Soc. Géol., France, ser. 4, vol. 22, 1922, pp. 76, 93.

Cisseis GUPPY, Quart. Jour. Geol. Soc. London, vol. 22, 1866, p. 584, pl. 26, fig. 19; a homonym of *Cisseis* LAPORTE and GORY, Hist. Nat. Écon. Ins. Coléopterès, vol. 2, 1839; a beetle.—HODSON, Am. Jour. Sci., ser. 5, vol. 12, 1926, p. 353; Bull. Am. Pal., vol. 12, no. 47, 1926, p. 8.

Asterocyclina GÜMBEL, Abh. k. bay. Ak. Wiss. München, Math.-Phys. Cl., for 1868, 1870, p. 716.—VAUGHAN, Jour. Pal., vol. 1, no. 4, 1928, p. 285.

Orthophragmina (part) SCHLUMBERGER, Bull. Soc. Géol. France, ser. 4, vol. 4, 1904, p. 126.—CUSHMAN, U. S. Geol. Surv. Prof. Pap. 108-G, 1917, p. 115; Prof. Pap. 125-D, 1920, p. 39.

Orthocyclina VAN DER VLERK, Verh. geol. Mijnb. Gen. Nederland Kol., Geol. Ser., vol. 7, 1923, p. 93, pl. 1.—DOUVILLÉ, Rev. Geol., vol. 5, 1924, p. 835; some chamberlets are subhexagonal.

Asteriacites (part) VAUGHAN, Bull. Geol. Soc. Am., vol. 35, 1924, p. 790.

Test biconvex, stellate, with 3 to 6 prominent radial ribs which extend beyond the general periphery of the test, consisting of a median zone of chambers, one layer only, divided by radial septa into quadrangular chamberlets, some of which may become subhexagonal, and several layers of chamberlets on each side of the median zone, with or without pillars; the annular chambers swing outward in the

rays, and the chamberlets are much larger in the rays than in the areas between; the microspheric nucleoconch is a planispiral coil of chambers divided into rectangular chamberlets; the megaspheric nusleoconch consists of a globular chamber partially surrounded by a larger chamber, which is immediately succeeded by the annular chambers; walls calcareous, with vestigial canal system, the lateral walls finely perforate. Diameter, up to 45 mm.—Middle and Upper Eocene of Europe, Upper Eocene of the Americas.

Subfamily 3. ORBITOIDINAE Prever, 1904

Orbitoidinae PREVER, Riv. Ital. Pal., vol. 10, 1904, p. 111.

Tests free, discoidal, flat, or sellaeform, consisting of a median zone of chambers which are arcuate, spatulate, ogival, rhombic or hexagonal in form, and a zone, with or without pillars, on each side of the median zone; microspheric nucleoconch planispiral; megaspheric nucleoconch with two or more chambers, variously arranged; walls calcareous, those of the median chambers made up of a median, thin, dark, granular layer, which is probably a vestigial canal system, on each side of which is a thick, light-colored layer made up of fibers at right angles to the median layer; the median walls are imperforate; walls of lateral chambers consist of a single, light-colored layer, which is finely or coarsely perforate; apertures consist of pores at each side of the base of the median chambers. Diameter, up to 80 mm.—Shallow water deposits.—Upper Cretaceous to Pliocene.

KEY TO GENERA

Nucleoconch central
- One layer median chambers
  - Megaspheric nucleoconch spiral
    - Median chambers spirally arranged ..... *Helicolepidina*
    - Median chambers not spirally arranged
      - Nucleoconch planispiral ..... *Polylepidina*
      - Nucleoconch trochoid spiral ..... *Clypeorbis*
  - Megaspheric nucleoconch not spiral
    - Qaudrilocular
      - Lateral zone many chambers deep ..... *Orbitoides*
      - Lateral zone one chamber deep ..... *Omphalocyclus*
    - Multilocular
      - Chambers subequal ..... *Simplorbites*
      - First chamber largest ..... *Pliolepidina*
    - Bilocular
      - Chambers subequal ..... *Cyclosiphon*
      - Chambers unequal
        - Second chamber slightly embracing first... *Lepidorbitoides*

Second chamber embracing half or more of first
Not entirely embracing first
Median chambers ogival.....*Nephrolepidina*
Median chambers spatulate .....*Amphilepidina*
Entirely embracing first .....*Eulepidina*
More than one layer of median chambers.....*Pseudorbitoides*
Nucleoconch eccentric
Subcentral .....*Miolepidocyclina*
Submarginal .....*Miogypsina*

Genus HELICOLEPIDINA Tobler, 1922

Genotype (monotypic) *Lepidocyclina (Helicolepidina) spiralis* TOBLER, Eclogae Geol. Helvetiae, vol. 17, 1922, p. 380, figs. 1-3. (Upper Eocene, Jackson, Rio San Pedro, Venezuela.)—DOUVILLÉ, ibid., 1923, p. 566; Bull. Soc. Géol. France, ser. 4, vol. 23, 1923, p. 369.—VAUGHAN, Proc. Nat. Acad. Sci., vol. 12, 1926, p. 533.—HODSON, Bull. Am. Pal., vol. 12, no. 47, 1926, p. 6.

Test discoidal, consisting of an equatorial zone of chambers between lateral zones; the equatorial zone is one chamber thick, and composed of chambers which are arcuate on the outside and varying to ogival, spatulate and subhexagonal, and arranged irregularly within a rapidly widening spire, with larger chambers on the inner side of the spire; the whorls are equitant; lateral chambers arranged in tiers with strong pillars between the tiers; surface strongly papillose; wall calcareous, those of lateral ones finely perforate; aperture an obscure V-shaped opening on the periphery; the nucleoconch in the megaspheric form consists of a spherical chamber followed by a hemispherical one; in the microspheric form, a spherical chamber followed by curved chambers as in *Camerina*. Diameter, up to 4 mm. —Upper Eocene of Venezuela, Trinidad and Ecuador.

Genus POLYLEPIDINA Vaughan, 1924

Genoholotype *Lepidocyclina (Polylepidina) chiapasensis* VAUGHAN, Bull. Geol. Soc. Am., vol. 35, 1924, pp. 794, 807, pl. 30, figs. 1-3, text fig. 4. (Eocene, 7 km. southeast of Chilon, Chiapas, Mexico.)—GALLOWAY, Jour. Pal., vol. 1, no. 4, 1928, p. 299.

Test discoidal; microspheric nucleoconch consisting of a minute, spherical chamber, followed by chambers which gradually enlarge, making two or three complete whorls, and gradually changing in shape from that of a sector to that of an arc, the wall of the first whorl thicker than that of succeeding chambers; megaspheric neucloconch consisting of a large, spherical chamber succeeded by 3 to 7 large but gradually decreasing, arcuate chambers arranged in nearly a complete coil, not separated from the succeeding, normal, median

chambers by any common, thick wall, but the walls of the first 2 or 3 chambers are thick; median chambers arcuate, with a curved outer wall and pointed or truncate proximal ends (as in *Orbitoides*), the adjacent chambers of the same annulus just touching and arranged in intersecting curves, or not touching and arranged in radial lines (*P. antillea* (Cushman)), and appearing rhombic in thick or opaque sections, with longer diameter parallel to the periphery of the test. Diameter, up to 20 mm.—Upper Cretaceous of Mexico; Eocene of Chiapas; Upper Eocene of Vera Cruz, Alabama, Mississippi, Lousiana, and Antilles.

Genus CLYPEORBIS Douvillé, 1915

Genoholotype *Clypeorbis mamillata* (SCHLUMBERGER) = *Orbitoides mamillata* SCHLUMBERGER, Bull. Soc. Géol. France, ser. 4, vol. 2, 1902, p. 259, pl. 8, figs. 17-20. (Late Cretaceous, Maestrichtian, Gensac, France.)

Clypeorbis, DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 669, figs. 18-20; Bull. Soc. Géol. France, ser. 4,, vol. 20, 1920, p. 227, figs. 29-34.

Test asymmetrically biconvex, conical on one side and nearly flat on the other, with a solid boss extending from the apex of the conical side to the center of the test; microspheric nucleoconch consisting of a proloculum followed by about two whorls of chambers which gradually enlarge and become arcuate; megaspheric nucleoconch consisting of a large proloculum which is followed by three or four smaller chambers arranged in a trochoid spire; median chambers spatulate to subhexagonal, arranged in radial lines; lateral chambers superimposed in tiers with prominent pillars, interrupted on one side by the solid cone. Diameter, up to 5 mm.—Late Cretaceous.

Silvestri considers *Clypeorbis* to be synonymous with *Lepidorbitoides* (Mem. Pont. Accad. Sci. Nuovi Lincei, vol. 10, 1927, p. 123).

Genus ORBITOIDES d'Orbigny, 1848

Genotype (first species figured, designated by SCHLUMBERGER, 1901) *Orbitoides faujasi* (DEFRANCE) = *Orbitolites media* D'ARCHIAC, Mém. Soc. Géol. France, vol. 2, pt. 1, 1835, p. 178, (Upper Cretaceous, Royon, France), a synonym of *Lycophris faujasi* DEFRANCE (misspelled *Licophris*), Dict. Sci. Nat., vol. 26, 1823, p. 272. (Upper Cretaceous, Mirambeau, France.) *Lycophris* MONTFORT, 1808, is unrecognizable. The name of the genotype thus becomes *Orbitoides faujasi* (DEFRANCE).

Orbitoides D'ORBIGNY, in LYELL, Quart. Jour. Geol. Soc. London, vol. 4, 1848, p. 12; Cours Élém. Pal., vol. 1, 1849, p. 193, fig. 316; vol. 2, fasc. 2, 1852, p. 689, fig. 557.—SCHLUMBERGER, Bull. Soc. Géol. France, ser. 4, vol. 1, 1901, p. 458, pl. 7, figs. 1-7.—DOUVILLÉ Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 666; vol. 169, 1919, p. 1133.

Hymenocyclus BRONN, Lethaea Geog., vol. 2, pt. 5, 1853, p. 94, pl. 29-1, fig. 29. A typonym of *Orbitoides*.

Silvestrina PREVER, Riv. Ital. Pal., vol. 10, 1904, p. 122, pl. 6, fig. 3; genotype (here designated) *Orbitoides apiculata* SCHLUMBERGER, Bull. Soc. Géol. France, ser. 4, vol. 1, 1901, p. 465, pl. 8, figs. 1, 4, 6; pl. 9, figs. 1, 4.—SILVESTRI, Mem. Pont. Accad. Rom. Nuovi Lincei, vol. 28, 1910, p. 125; Mem. Pont. Accad. Sci. Nuovi Lincei, vol. 10, 1927, p. 110.

Orbitella DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 666, figs. 5-12; Bull. Soc. Géol. France, ser. 4, vol. 20, 1920, p. 214. A typonym of *Orbitoides*.

Test lenticular, composed of a median zone of chambers, and two lateral zones of chambers in vertical tiers, with pillars; the median chambers have arcuate outer walls, which are arranged annularly, alternating, and in spiral lines to the right and to the left, so that each chamber is bound by an arcuate outer wall and a half of each of the two adjacent chambers of the previous annulus; wall calcareous, with vestigial mural canal system, the lateral walls finely perforate; there are one or more foramina at either side of the base of each arcuate wall; the megaspheric nucleoconch is quadrilocular, surrounded by a thick wall; microspheric form not definitely known. Diameter, up to 15 mm.—Upper Cretaceous, Europe, India, and Tibet.

Genus OMPHALOCYCLUS Bronn, 1853

Genotype (monotypic) *Omphalocyclus macropora* (LAMARCK) = *Orbulites macropora* LAMARCK, Syst. Anim. s. Vert., vol. 2, 1816, p. 197. (Upper Cretaceous, Maestrichtian, Maestricht, Holland.) (*Orbulites* LAMARCK, 1801, is a cephalopod.)

Cupulites LAMOUROUX, Expos. Méth. Polyp., 1821, p. 44. A vernacular name.

Omphalocyclus BRONN, Lethaea Geog., ed. 3, vol. 2, pt. 5, 1853, p. 95, pl. 29, fig. 9.—DOUVILLÉ, Bull. Soc. Géol. France, ser. 4, vol. 20, 1920, p. 228. Bibliography.—SILVESTRI, Atti Pont. Accad. Rom. Nuovi Lincei, vol. 61, 1907, p. 19.

Test free, discoidal, increasing in thickness toward the margin, consisting of an equatorial zone of chambers which are annularly arranged, and two lateral zones of chambers arranged in intersecting curves turning to the right and to the left, each zone being one chamber thick; each chamber communicates by a pore with each of the two preceding and the two succeeding chambers, and with the chamber adjoining it laterally; the nucleoconch of the microspheric form is a planispiral coil of chambers, in the megaspheric form it consists of four subequal chambers bounded by a thick wall; walls calcareous, thick, the lateral covering of each chamber of the lateral zones conspicuously perforate, the wall between chambers fibrous and imperforate; walls between chambers raised at the surface and thickened;

apertures are rounded pores in three or five parallel rows on the periphery of the test. Diameter, 2 to 12 mm.—Upper Cretaceous, Maestrichtian, of Holland, France, Italy, Tunis, Sicily, Rumania, Baluchistan, India and Tibet.

The relationships of this genus are in doubt, but the structure is more like that of the orbitoids than that of any other family.

Genus SIMPLORBITES De Gregorio, 1882

Genotype (first species, here designated) *Simplorbites cupulinus* DE GREGORIO, Fossili dei Dintorni di Pachino, Palermo, 1882, p. 10, pl. 6, figs. 21, 22. (Upper Cretaceous, Sicily.)—DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 667, figs. 13-15; Bull. Soc. Géol. France, ser. 4, vol. 20, 1920, p. 217, figs. 19-21.

Test discoidal, composed of a median and lateral zones of chambers, the nucleoconch composed of a large number of chambers, irregularly arranged, which resemble the median chambers or are cystic, and inclosed by a very thick wall; median chambers arcuate, arranged annularly and alternately, with a foramen on each side of the base of each arcuate chamber; lateral zones of chambers with pillars. Diameter, up to 51 mm.—Late Cretaceous, Maestrichtian, Sicily, southern France, and Carpathians.

Simplorbites may be a pathologic or degenerate form of *Orbitoides*.

Genus PLIOLEPIDINA Douvillé, 1915

Genotype (monotypic) *Pliolepidina tobleri* DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 164, 1917, p. 844, figs. 5, 6. (Upper Eocene, Point Bontour, Trinidad.)

Pliolepidina DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 727, fig. 34, no species named.—VAUGHAN, Proc. Nat. Acad. Sci., vol. 9, 1923, p. 255; Bull. Geol. Soc. Am., vol. 35, 1924, p. 794.—DOUVILLÉ, Mém. Soc. Géol. France, n. s., vol. 1, mém. 2, 1924, p. 43, figs. 34, 35.

Multicyclina CUSHMAN, U. S. Nat. Mus. Bull 103, 1918, p. 96, pl. 41, figs. 2-4. Type *Lepidocyclina (Multicyclina) duplicata* CUSHMAN (Upper Eocene, David, Panama), supposedly distinguished by several layers of median chambers near the periphery.

Megaspheric nucleoconch consisting of one large chamber with several smaller ones around it; microspheric nucleoconch planispiral with gradually enlarging chambers; median chambers spatulate, in thick or opaque sections appearing hexagonal near the center and diamond-shaped near the periphery of the test, with radial diameter the longer. Diameter, 2 to 14 mm.—Upper Eocene, Trinidad, Panama and Venezuela; doubtfully in the Oligocene.

Genus PSEUDORBITOIDES Douvillé, 1922

Genoholotype *Pseudorbitoides trechmanni* DOUVILLÉ, Com. Ren. Somm. Séan. Soc. Géol. France, Dec. 18, 1922, p. 203, fig. 1; Bull. Soc. Géol. France, ser. 4, vol. 23, 1923, p. 369, figs. 1, 2. (Upper Cretaceous, Jamaica.)

Test discoidal, biconvex, consisting of a median zone of chambers which is one chamber thick for the first third of the radius of the test, two chambers thick in the second third, and three chambers thick in the outer third of the radius, and two lateral series of chambers; microspheric nucleoconch planispiral, megaspheric unknown; equatorial chambers arcuate and arranged in radial lines. Diameter, about 5 mm.—Upper Cretaceous, Jamaica.

Pseudorbitoides is incompletely known. It may be the microspheric form of *Polylepidina.*

Genus LEPIDORBITOIDES Silvestri, 1907

Genotype (monotypic) *Lepidorbitoides socialis* (LEYMERIE) = *Orbitolites socialis* LEYMERIE, Mém. Soc. Géol. France, ser. 2, vol. 4, 1851, p. 191, pl. 9, fig. 5. (Upper Cretaceous, Maestrichtian, Gensac and Saint-Marcet, Haute-Garonne, France.)

Lepidorbitoides SILVESTRI, Boll. Natur. Siena, vol. 27, 1907, p. 11; Riv. Ital. Pal., vol. 13, 1907, p. 80; Atti Pont. Accad. Nuovi Lincei, vol. 61, 1907, pp. 18, 23; ibid., vol. 61, 1908, p. 94; Mem. Pont. Accad. Nuovi Lincei, vol. 28, 1910, pp. 119, 129; ibid., vol. 10, 1927, p. 109.—SCHUBERT, Neues Jahrb., 1911, pt. 1, p. 334.—DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 668, figs. 16, 17; ibid., vol. 169, 1919, p. 1135; Bull. Soc. Géol. France, ser. 4, vol. 20, 1920, p. 220, figs. 22-27, pl. 8, figs. 1-4.

Test discoidal, biconvex, consisting of a median zone and two lateral zones of chambers, with or without pillars; microspheric nucleoconch planispiral; megaspheric nucleoconch bilocular, a spherical chamber partially surrounded by a larger, spherical chamber, both inclosed by a thick, common wall; early equatorial chambers arcuate as in *Orbitoides,* later ones spatulate, appearing hexagonal in thick sections, as in typical *Cyclosiphon.* Diameter, 2 to 16 mm.—Characteristically Late Cretaceous, Maestrichtian, doubtfully Lower Eocene (Douvillé, 1920).

Genus CYCLOSIPHON Ehrenberg, 1855

Genotype (monotypic) *Cyclosiphon mantelli* (MORTON) = *Nummulites mantelli* MORTON, Am. Jour. Sci., vol. 23, 1833, p. 291, pl. 5, fig. 9. (Lower Oligocene, Marianna limestone, near Claiborne, Alabama.)

Orbitoides (part) CARPENTER, Quart. Jour. Geol. Soc. London, vol. 6, 1850, p. 32, pl. 6, figs. 20, 21; pl. 7, fig. 31. Topotypes.

Cyclosiphon EHRENBERG, Bericht k. preuss. Ak. Wiss. Berlin, 1855, p. 288; Abh. k. Ak. Wiss. Berlin, Phys.-Math. Cl., for 1855, 1856, p. 145.

Lepidocyclina GÜMBEL, Abh. k. bay. Ak. Wiss., München, Math.-Phys. Cl., for 1868, 1870, pp. 689, 717, genotype (designated by DOUVILLÉ, 1898) *Nummulites mantelli* MORTON.—DOUVILLÉ, Bull. Soc. Géol. France, ser. 3, vol. 26, 1898, p. 394.—SCHLUMBERGER, ibid., ser. 4, vol. 1, 1901, p. 464.—R. DOUVILLÉ, ibid., ser. 4, vol. 7, 1907, pp. 51, 307.—H. DOUVILLÉ, ibid., p. 466.—LEMOINE and DOUVILLÉ, Mém. Soc. Géol. France, Pal., mém. 32, 1904.—SCHUBERT, Verh. k. k. geol. Reichs., 1910, p. 395.—DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 724; vol. 167, 1918, p. 263.—YABE, Sci. Rep. Tohoku Imp. Univ., Sendai, Japan, ser. 2, Geol., vol. 5, 1919, p. 41.—SILVESTRI, Mem. Pont. Accad. Rom. Nuovi Lincei, vol. 29, 1911, pp. 56-77 (bibliography).—CUSHMAN, U. S. Nat. Mus. Bull. 103, 1919, p. 89; U. S. Geol. Surv. Prof. Pap. 125-D, 1920, p. 57.—VAN DER VLERK, Verh. geol. Mijnb. Gen. Nederland Kol., Geol. Ser., vol. 5, 1922.—DOUVILLÉ, Mém. Soc. Géol. France, n. s., vol. 1, mém. 2, 1924.—VAUGHAN, Bull. Geol. Soc. Am., vol. 35, 1924, p. 794.

Isolepidina DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 724, a typonym; Mém. Soc. Géol. France, n. s., vol. 1, mém. 2, 1924, p. 34.

Test discoidal, flat or sellaeform, consisting of a median zone of chambers, and lateral zones with or without pillars; the microspheric nucleoconch is a planispiral coil of a few gradually enlarging chambers; the megaspheric nucleoconch consists of two subequal chambers (*Cyclosiphon, sensu stricto*), or two unequal chambers, one partially embracing the other (*Nephrolepidina* and *Amphilepidina*), or entirely embracing the other (*Eulepidina*); median chambers arcuate in the young of the microspheric generation, as in *Orbitoides*, or more commonly spatulate and appearing hexagonal with round chamber cavity in thick or opaque sections (*Lepidocyclina, sensu stricto, Amphilepidina, Eulepidina*), or ogival and appearing rhombic (diamond-shaped, lozenge-shaped) in thick or opaque sections (*Nephrolepidina*); lateral chambers usually in vertical tiers, varying much in shape in different species and at different levels in the same specimen, the walls consisting of a single layer of light-colored tissue, that part opposite the chamber cavity finely perforate but elsewhere imperforate; median chamber walls consisting of three layers, a median, granular, dark-colored, thin layer, probably representing a mural canal system, on each side of which is a thick, light-colored layer made up of fibers at right angles to the median layer; the shape of the median chambers is determined by the thin, dark layer; each chamber in the median zone has one or more foramina at each side of the base of the outer, curved wall, connecting adjacent chambers in the same annulus, which foramina, in forms with spatulate chambers, occur in circles, suggesting to Ehrenberg the name *Cyclosiphon;*

sometimes the median chamber wall does not reach the base of the chamber, and then the foramen opens into a chamber of the succeeding annulus; surface smooth or pustulate. Diameter, 2 to 80 mm., the microspheric form several times larger than the megaspheric form of the same species.—Eocene common, Oligocene abundant, Miocene uncommon, Pliocene very rare (Schubert).

Genus CYCLOSIPHON

Subgenus CYCLOSIPHON Ehrenberg, 1855

Isolepidina DOUVILLÉ, 1915, a typonym of *Cyclosiphon*.
Lepidocyclina, sensu stricto, of authors.

Megaspheric nucleoconch consisting of two subequal chambers surrounded by a thick wall and separated by a thin, flat septum; median chambers arcuate (as in *Orbitoides* and *Polylepidina*) in the young, becoming closer appressed tangentially to the test in the adult, producing a spatulate form of chamber with flat, parallel side walls and arcuate outer wall, appearing hexagonal particularly in thick or opaque sections.—Upper Eocene and Oligocene.

Genus CYCLOSIPHON

Subgenus NEPHROLEPIDINA Douvillé, 1911

Genotype (designated by YABE, 1919) *Cyclosiphon (Nephrolepidina) marginatus* (MICHELOTTI) = *Nummulites marginata* MICHELOTTI, Mem. Soc. Ital. Sci., vol. 22, 1841, p. 297, pl. 3, fig. 4. (Upper Oligocene, or Lower Miocene, near Turin, Italy.)

Nephrolepidina DOUVILLÉ, Philippine Jour. Sci., sec. D, vol. 6, no. 2, 1911, pp. 59, 73; Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 727, fig. 33.—YABE, Sci. Rep. Tohoku Imp. Univ., Sendai, Japan, ser. 2, Geol., vol. 5, no. 2, 1919, pp. 41, 47.—DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 175, 1922, p. 552; Mém. Soc. Géol. France, n. s., vol. 1, mém. 2, 1924, p. 46.—YABE and HANZAWA, Verh. geol. Mijnb. Gen. Nederland Kol., Geol. Ser., vol. 8, 1925, p. 617.

Lepidocyclina (part) LEMOINE and DOUVILLÉ, Mém. Soc. Géol., Pal., mém. 32, 1904, p. 16, pl. 2, fig. 7, type of *Nummulites marginata* MICHELOTTI refigured.

Megaspheric nucleoconch consisting of two inequal chambers, the larger embracing about half of the smaller one, both surrounded by a thick wall; median chambers ogival, appearing rhombic radially or elongate hexagonal radially, in thick or opaque sections.—Upper Eocene, Oligocene and Lower Miocene.

Genus CYCLOSIPHON

Subgenus AMPHILEPIDINA Douvillé, 1922

Genotype (first species, here designated) *Cyclosiphon (Amphilepidina) sumatrensis* (BRADY) = *Orbitoides sumatrensis* BRADY, Geol. Mag., dec. 2, vol. 2, 1875, p. 536, pl. 14, fig. 3. (Upper Oligocene or Lower Miocene, Sumatra.)

Orbitoides (Lepidocyclina) NEWTON and HOLLAND, Ann. Mag. Nat. Hist., ser. 7, vol. 3, 1899, p. 259, pl. 10, figs. 7, 8. Type refigured.

Amphilepidina DOUVILLÉ, Com. Ren. Acad. Sci., Paris, vol. 175, 1922, p. 553; Mém. Soc. Géol. France, n. s., vol. 1, mém. 2, 1924, p. 44.—VAUGHAN, Proc. Nat. Acad. Sci., vol. 12, 1926, p. 520.

Megaspheric nucleoconch bilocular, consisting of a large chamber nearly embracing a smaller one, both surrounded by a thick wall; median chambers spatulate, appearing hexagonal in thick or opaque sections.—Upper Eocene rare, Oligocene common, Lower Miocene rare.

Amphilepidina differs from *Nephrolepidina* in the spatulate instead of ogival median chambers, a difference scarcely of even subgeneric rank, since both forms occur in the same specimen, the subgenera are identical in all other respects, including geologic and geographic range.

Genus CYCLOSIPHON

Subgenus EULEPIDINA Douvillé, 1911

Genotype (designated by YABE, 1919) *Cyclosiphon (Eulepidina) dilatatus* (MICHELOTTI) = *Orbitoides dilatata* MICHELOTTI, Nat. Verh. Holland. Maat. Wet. Haarlem, vol. 15, 1861, p. 17, pl. 1, figs. 1, 2. ("Lower Miocene", northern Italy.)

Eulepidina DOUVILLÉ, Philippine Jour. Sci., sec. D, vol. 6, no. 2, 1911, p. 59; Com. Ren. Acad. Sci., Paris, vol. 161, 1915, p. 726, figs. 31, 32; ibid., vol. 175, 1922, p. 552; Mém. Soc. Géol. France, n. s., vol. 1, mém. 2, 1924, p. 48.—YABE, Sci. Rep. Tohoku Imp. Univ., Sendai, Japan, ser. 2, Geol., vol. 5, no. 2, 1919, p. 41.—VAUGHAN, Bull. Geol. Soc. Am., vol. 35, 1924, p. 794.—NUTTALL, Quart. Jour. Geol. Soc. London, vol. 82, pt. 1, 1926, p. 22.

Lepidocyclina (part) LEMOINE and DOUVILLÉ, Mém. Géol., Pal., mém. 32, 1904, p. 13, fig. 3, after the figure by MICHELOTTI.

Megaspheric nucleoconch bilocular, consisting of two spherical chambers, one completely embracing the other, the two touching tangentially and surrounded by a thick wall; median chambers spatulate, appearing hexagonal in thick or opaque sections.—Oligocene and Lower Miocene and Pliocene.

Genus MIOLEPIDOCYCLINA Silvestri, 1907

Genotype (monotypic) *Miolepidocyclina burdigalensis* (GÜMBEL) =*Orbitoides (Lepidocyclina) burdigalensis* GÜMBEL, Abh. k. bay. Ak. Wiss., München, Math.-Phys. Cl., vol. 10, for 1868, 1870, p. 719, not figured. (Lower Miocene, Aquitanian, near Bordeaux, France.)

Miolepidocyclina SILVESTRI, Boll. Natur. Siena, vol. 27, 1907, p. 11; Riv. Ital. Pal., vol. 13, 1907, p. 80; Mem. Pont. Accad. Nuovi Lincei, vol. 28, 1910, pp. 119, 137.

Miogypsina (part) SCHLUMBERGER, Bull. Soc. Géol. France, ser. 3, vol. 28, 1900, p. 330, pl. 2, figs. 11, 12; pl. 3, figs. 22-25. Topotypes.

Heterosteginoides CUSHMAN, U. S. Nat. Mus. Bull. 103, 1919, p. 97; Carnegie Inst. Washington, Pub. 291, 1919, p. 50.

Test discoidal, asymmetrical, subpolygonal, consisting of a median zone of chambers and lateral zones with pillars; the nucleoconch is eccentric, nearer the center than to the periphery of the test, and planispiral, both micro- and mega-spheric forms as in *Miogypsina;* median chambers spatulate to ogival in shape and varying much in size and irregularly arranged, in equatorial section, and round in vertical section. Diameter, 2 to 4 mm.—Oligocene and Lower Miocene.

Miolepidocyclina is intermediate between *Cyclosiphon, sensu stricto,* and *Miogypsina.*

Genus MIOGYPSINA Sacco, 1893

Genoholotype *Miogypsina globulina* (MICHELOTTI) =*Nummulites globulina* MICHELOTTI, Mem. Soc. Ital. Sci., vol. 22, 1841, p. 397, pl. 3, fig. 6. (Lower Miocene, Aquitanian, near Turin, Italy.)

Miogypsina SACCO, Bull. Soc. Belge Géol., vol. 7, Nov. 28, 1893, p. 205.—SCHLUMBERGER, Bull. Soc. Géol. France, ser. 3, vol. 28, 1900, p. 327, pl. 2, fig. 8, topotype.—SCHUBERT, Verh. k. k. geol. Reichs., 1910, p. 395.—VAUGHAN, Bull. Geol. Soc. Am., vol. 35, 1924, p. 802.—HODSON, Bull. Am. Pal., vol. 12, no. 47, 1926, p. 28.

Flabelliporus DERVIEUX, Atti R. Accad. Sci. Torino, vol. 29, Dec. 3, 1893, p. 57; Riv. Ital. Pal., vol. 6, 1900, p. 146.

Lepidosemicyclina RUTTEN, Proc. Sci. Ak. Wet. Amsterdam, vol. 13, 1911, p. 1135.

Test lenticular, biconvex, asymmetrical, consisting of a median zone of chambers and lateral zones with pillars; the nucleoconch is situated very near the periphery of the test, and consists, in the microspheric form, of gradually enlarging chambers in one or two whorls, in the megaspheric form, of two subequal, globular chambers which are followed by gradually decreasing, spatulate chambers in about one whorl; median chambers mostly diamond-shaped, with longer axis radially, sometimes ogival or elongate hexagonal, arranged in inter-

secting curves; in transverse section the median chambers are round; wall calcareous, thick; surface unevenly rugose or unequally pustulate. Diameter, 1 to 10 mm.—Upper Oligocene uncommon, Miocene common, Pliocene (Schubert) rare.

FUSULINELLAS FROM THE STONEFORT LIMESTONE MEMBER OF THE TRADEWATER FORMATION*

By LLOYD G. HENBEST

(Read before the Paleontological Society. December 29, 1927)

INTRODUCTION

The specimens that form the basis of this report were collected in 1925-6 and studied in 1927. The writer is indebted to Dr. M. M. Leighton, Chief, and Dr. Gilbert H. Cady, Senior Geologist, Illinois State Geological Survey, for helpful suggestions and for furnishing the facilities for this work. Acknowledgment for some of the collections is given with the collecting locality notes.

The stratigraphic position of the Stonefort limestone member of the Tradewater formation, Pottsville group, is shown by the columnar section in figure 1. This limestone member or its limy shale equivalent is persistent in southeastern Illinois and probably extends into Kentucky.

MICRO-FAUNAL ASSOCIATIONS

In the stonefort limestone, *Textularia, Bigenerina, Tetrataxis,* and "worm tubes" are numerous. *Climacammina, Endothyra,* and *Valvulina?* are less common. The so-called "worm tubes" are by far the most numerous of all and occur in several species. *Tetrataxis* is present in at least three species that are easy to distinguish by their geometric forms. Two of these species appear like *Tetrataxis linea* Ozawa and *T. conica* Ehrenberg. A few ostracod shells are present.

With this micro-fauna, *Fusulinella* of the plicated septa type are rare. *F. euthusepta* n. sp. and *F. minuta* n. sp. are less rare, but not numerous.

* By permission of the Chief, Illinois State Geological Survey.

NOTES ON THE GENUS FUSULINELLA WITH SPECIAL REFERENCE TO F. VENTRICOSA

Order FORAMINIFERA

Family FUSULINIDAE Möller

Genus FUSULINELLA Möller

So much confusion has arisen over the classification of the Fusulinas that group names do not mean much unless they are defined to some extent by each person who uses them. The lack of an adequate classification caused considerable difficulty in classifying

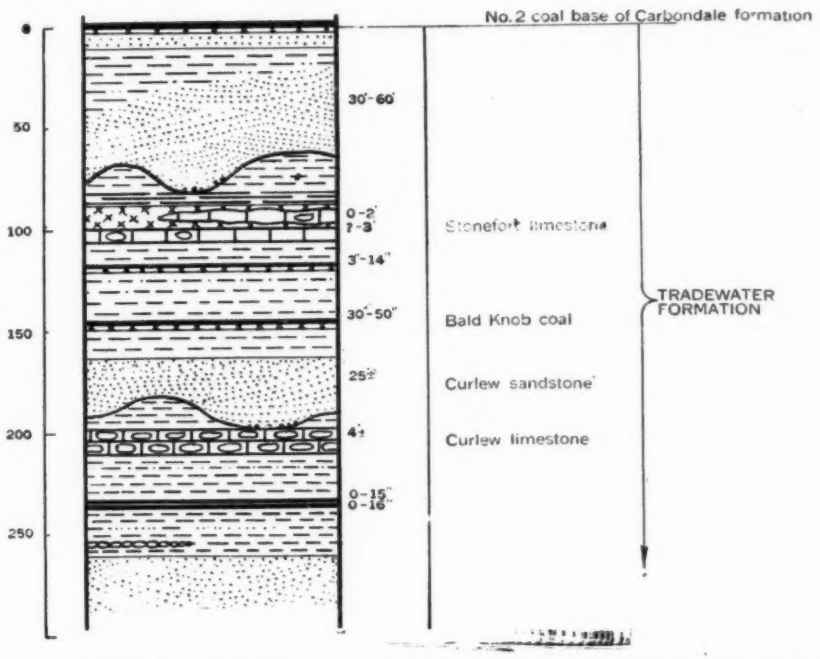


FIG. 1.—Generalized columnar section showing the upper portion of the Tradewater formation.

the Stonefort specimens because some of the classifications that have been proposed use different generic names for the same form.

The genus *Fusulinella* was erected by von Möller in 1877 for *Fusulina bocki* which differed from other Fusulinas by having no meshwork structure in the transparent layer that corresponds in position to the meshwork of *Fusulina* s. s. In Schellwien's unfinished monograph,[1] the name *Fusulinella* was used in Möller's sense and

[1] Monographie der Fusulinen: Paleontographica, Teil III, Band 59, 1912.

Schellwien included in this genus at least one form which had strongly folded septa in addition to the typical features of *Fusulinella*. After Schellwien's death, the manuscript of his unfinished monograph was given to von Staff to finish. Among a number of other changes, von Staff substituted the new name *Girtyina* for the *Fusulinella* with strongly folded septa, and with Wedekind[2] set this new genus apart from *Fusulinella* by establishing two new sub-families, as follows:

Sub-family FUSULINELLINAE Staff and Wedekind

Genus FUSULINELLA Möller em. Staff

Genus SCHUBERTELLA Staff and Wedekind

Sub-family FUSULININAE Staff and Wedekind

Genus GIRTYINA Staff

Genus FUSULINA F. von Waldheim

Sub-genus SCHELLWIENIA Staff and Wedekind

Sub-genus SCHWAGERINA Möller em. Staff

The one feature that was supposed by them to differentiate all forms in one group from those in the other was the symmetry of the earlier volutions. The earlier volutions of the *Fusulinellinae* were supposed to be asymmetrical or endothyran,[3] where as those in the Fusulininae were almost bisymmetrial. It is now known that von Staff confused the form now known as genus *Staffella* Ozawa with *Fusulinella* as typical of the latter genus. In the infant stage, *Saffella* is endothyran.

This classification has not been in good standing everywhere if one may judge by the more recent contributions of Deprat[4] and Ozawa[5] which differed from that of von Staff, although his work was taken into consideration.

The early whorls of *Fusulinella minuta* n. sp. are symmetrical and those in *F. euthusepta* n. sp. slightly asymmetrical but not notably so. *Fusulinella bocki* Möller also has symmetrical early whorls if one may judge by Ozawa's illustration[6] of it; therefore, the placing of the

[2] H. von Staff and Wedekind, Der Oberkarbone Foraminiferensapropelit Spitzbergens: Bull. Geol. Inst. Univ. Upsala, vol. X, 1910-11.

[3] Id est, like an Endothyra which is supposed by some to be the ancestor of all Fusulinas.

[4] Deprat, J., Des Fusulinides de la Chine et de l'Indochine et Classification de Calcaires a Fusulines: Mem. Serv. Geo. l'Indochine, vol. 1, fasc. 3, p. 8, 1912.

[5] Ozawa, Yoshiaki, On the Classification of Fusulinidae: Jour. Coll. Sci. Imp. Univ. Tokyo, XLV., art. 4, pp. 4-7, 1925.

[6] Ozawa, Y., Paleontological and Stratigraphical Studies on the Permo-carboniferous Limestone of Nagato: Jour. Coll. Science, Imp. Univ. Tokyo, vol. XLV, art. 6; plate III, figs. 7, 9, and 10, 1925.

Fusulinella bocki type into a separate sub-family from the *Fusulinella ventricosa* type cannot hold. The only other large difference is folding of the septa.

Fusulinella bocki Moller, *F. itoi* Ozawa, *F. minuta* n. sp., and *F. euthusepta* n. sp. have more or less septal folding in the umbilical zones, but little if any in the median portion. A group of several species of Fusulinellas have intensely folded septa throughout their entire length, excepting only the portion above the tunnel or buccal aperture. The best known example of this kind is *F. ventricosa* (Meek and Worthen?) from Illinois. No form has been described yet that shows obviously an intermediate degree of folding[7] between both types, but slight and regular flexures of the septa may be seen in certain sections of *F. euthusepta.* Not many investigators seem to have held the opinion that the degree of septal folding has more than specific value for the *Fusulinella;* and, inasmuch as variations in the degree of septal folding exist within the group of non-folded septa type of Fusulinellas and also within the group of the intensely folded type, the writer believes it best to retain the original name *Fusulinella* Möller and discard the name *Girtyina* Staff.

The name *Girtyina ventricosa* has been used indiscriminately in Illinois for any fusulinid that has a ventricose or inflated form. This confusion has been due partly to the lack of a careful and exhaustive study of the form, but more especially to the use of size and exterior form as the only criteria for identification, which, of course, are useful criteria only when taken with data on the internal structure. For a long time, *Fusulinella ventricosa* was considered an index fossil for the limestone cap rock of No. 6 coal, especially where the specimens were abundant. However, the discovery of fairly numerous ventricose fusulinids in the Bankston Creek limestone (40 feet above the limestone cap rock) and the discovery of similar forms in the Stonefort limestone member, extends the range of the ventricose fusulinids from upper Pottsville well into the McLeansboro. Therefore, the use of ventricose fusulinids as index fossils have little or no value when their identification is based only on size and exterior form.

General Character of the Stonefort Limestone Species

The specimens of *Fusulinella* from the Stonefort limestone all possess features that leave no doubt about their generic position.

[7] Recently, a Fusulinella from the Curlew limestone (see fig. 1) was found which has an intermediate degree of folding between the type represented by F. enthusepta and the type represented by F. ventricosa. It is to be described in a later paper.

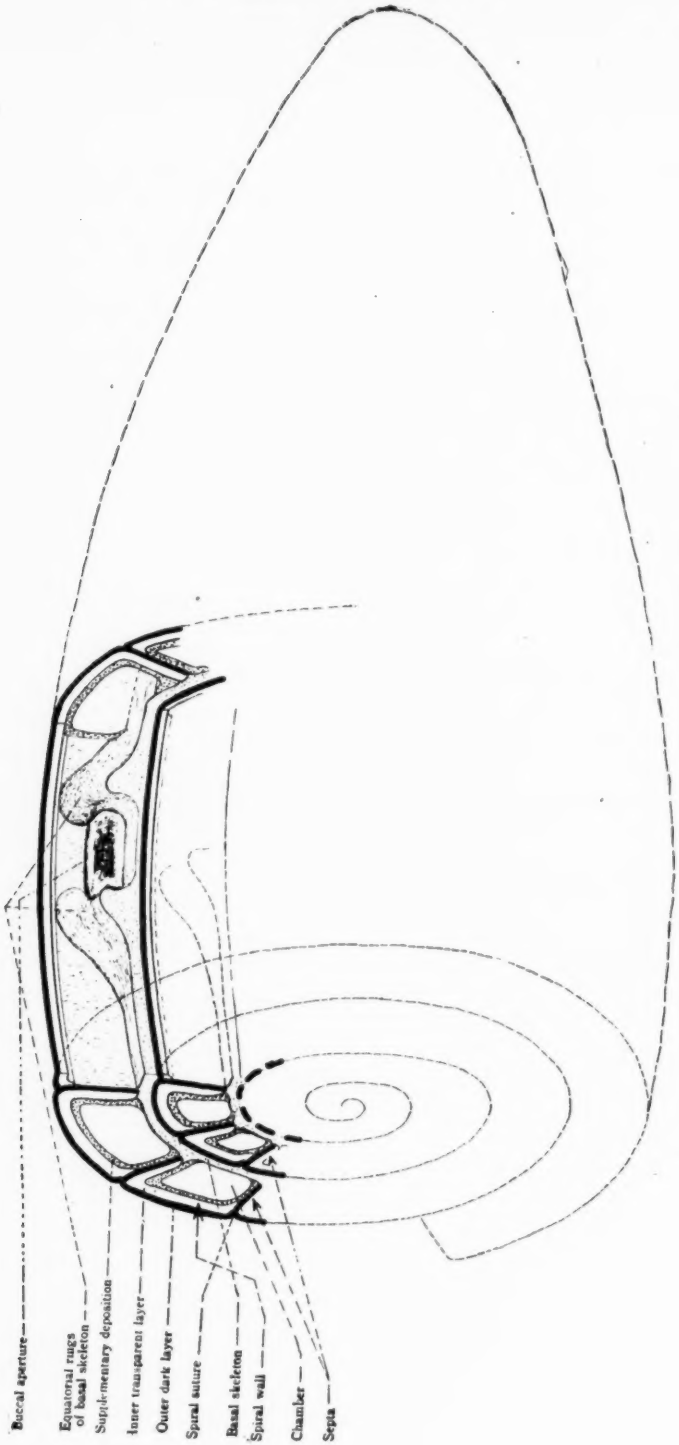


FIG. 2.—Diagram of a *Fusulinella* having non-folded septa.

In all of them, the axis is the longest dimension. The shell wall consists of a primary and a supplementary or secondary shell structure (see fig. 2). The primary shell structure is composed of two layers —the outer or dark layer (dachblatt) and the inner or transparent layer (zwischenraum). The dark layer is thin and nearly opaque. The transparent layer is much thicker and is structureless. This last feature distinguishes it from the corresponding layer in the group of *Fusulina* s. s. which has a meshwork structure as shown in plate 8, figure 1.

The secondary shell structure is also composed of two layers—the basal skeleton and the supplementary deposition. The basal skeleton is deposited on the outside of each whorl excepting the last one, or to state it more logically perhaps, on the floors of the chambers.

The basal skeleton is less transparent and has a duller appearance than the inner transparent layer (zwischenraum) of the primary shell structure. It fills the septal furrows below and ankyloses with the bases of the septa that belong to the whorl above, excepting the portion of the septa over the buccal aperture.

In the equatorial zone, a canal begins at the aperture of the initial chamber and extends in a planospiral direction to the exterior. This canal is a channel in the basal skeleton; and on each side of the canal a levee is formed by the basel skeleton. This levee strongly reinforces the septa in the equatorial region. In most Fusulinellas these levees are massive, but *F. euthusepta* n. sp. is notable for the lack of massive levees. In most species, the basal skeleton is thickest in the middle and thins out toward the poles.

The supplementary deposition layer covers the posterior and anterior faces of the septa—except the exterior face of the last septum and the inside of the spiral wall. It meets the basal skeleton near the base of the septa. This substance has the same diaphaneity as the basal skeleton and the contact between these two structures can not be distinguished in the Stonefort specimens.

The absence of meshwork structure, the presence of supplementary deposition together with massive basal skeleton, the presence of more or less massive levees of basal skeleton on each side of the bucal aperture, and the fusiform or cylindrical form make it certain that the species of Fusulinas from the Stonefort limestone member belong to the genus *Fusulinella* Möller.

DESCRIPTION OF SPECIES

FUSULINELLA (GIRTYINA) aff. VENTRICOSA (Meek and Worthen?)

Plate 10, figs. 5 and 7

1873. ?*Fusulina ventricosa* MEEK and WORTHEN, Geol. Surv. Ill., vol. 5, p. 560, pl. XXIV.
1874. ?*Fusulina ventricosa* MEEK, Am. Jour. Sci., (series 3), vol. 7, p. 484.
1912. *Girtyina ventricosa* VON STAFF, Paleontographica, Band 59, Teil III, pp. 164-5 et cetera, Tafel XVIII.
1922. ?*Girtyina ventricosa* MORNINGSTAR, Pottsville Fauna of Ohio: Geol. Surv. Ohio, 4th ser., Bull. 25, p. 153, pl. VI, fig. 4.
1925. *Girtyina ventricosa* CADY, Ill. State Geol. Surv., Rept. of Investigations No. 2, Description and 2 figures, pp. 8-9.

Description. Ventricose. Inflated. The ends are rather blunt. Form ratio is near 1:1.8. Axis is nearly straight. Surface marked by shallow, meridional furrows of medium width. Furrows are bent forward at center and at poles, but lag in the two intermediate regions. Initial chamber is large and somewhat elliptical. The wall is about 0.022 mm. thick. Bucal aperture is $\frac{2}{5}$ of the height of the chamber and maintains the same form throughout. The basal skeleton, except at the two spiral levees, is about as thick as the rest of the shell wall in the equatorial region, but thins out toward the poles. Supplementary deposition inside the spiral wall and on both sides of the septa is moderate in thickness and also thins out toward the ends. Secondary shell structures are much diminished in the last whorl.

Meshwork is obsolete. The inner, transparent layer (zwischenraum), is bent inward with the outer dark layer to form the septa. The spiral wall of each chamber abuts against the top of the preceding septum with considerable thickening downward to reinforce the synarthrosis or spiral suture.

The septa are greatly and regularly folded. The zone of folding includes all of the septa, except a small portion near the spiral suture which is about as wide as the suture. The nonfolded portion of the septa pitches forward at an angle with the radial vector of about 30° but considerable variation from this is common.

Spiral walls and septa have about the same thickness throughout.

Curves plotted for these figures are nearly parabolic, except for a slight bend near the portion of the last whorl which represents a decrease in rate of growth and in the rate of chamber addition, in what is probably the gerontic stage.

Statistics of cross-section

No. of Whorls	Radial vector in mm.	Cumulative No. chambers
Initial Chamber	.085*	
1	.165	10½
2	.263	30
3	.385	53
4	.544	77?
5	.691	104
6	.901	136
7	1.186	172
8	1.402	218?†

*Diameter of the initial chamber is .170 mm.
†8½ volutions 224 chambers in all.

Statistics of axial section

No. of Whorls	Axial length in mm.	Diameter in mm.	Form ratio
Initial Chamber		.140	
1	.480	.312	1:1.2
2	.840	.504	1:1.6
3	1.282	.744	1:1.7
4	1.920	1.056	1:1.8
5	2.592	1.416	1:1.83
6	3.576	1.920	1:1.86
7	4.296	2.328	1:1.84
8	4.992	2.784	1:1.79

Development of the shell by stages

Cross-section	Axial section
Nepionic stage	
Initial chamber is large	The initial chamber is large
Neanic stage	
2½-2¾ volutions in this stage. Closely wound. Rate of growth gradually increases. No abrupt change to mark end of stage. After first volution full thickness of walls is attained. Septa and spiral walls nearly the same thickness.	2-3 volutions in this stage. Rate of growth gradually increases. Slight quickening near third volution. Septa are folded only in polar zones. Obese. Symmetrical.

Ephebic and Gerontic stages

Volutions (2½-2¾) to 8⅕ in these stages.	Volutions (2-3) to 8 in these stages.
Gradual increase in rate of growth till whorl 7¼ where gerontic stage may begin. Basal skeleton supports the septa except at the slits or apertures made by the folding of the septa. The septa are strongly folded.	Inflation begins between second and third volutions and diminishes in the seventh and eighth. The septa are strongly folded.

Remarks. As no exhaustive study has been made of *F. ventricosa* from the limestone "cap rock" of No. 6 coal, the reference of the Stonefort limestone form to *F. ventricosa* is made with uncertainty. For comparison, several thin sections were made of the "cap rock" form which showed some differences that may prove to be significant. An average specimen from the "cap rock" has 272 chambers in eight whorls, whereas one of the same size from the Stonefort limestone has about 256 chambers in eight whorls. Another difference is found in the thicker and somewhat more extensive basal skeleton in the Stonefort limestone form, but the levees of basal skeleton beside the buccal aperture are less massive than in the "cap rock" specimens. In general, the shell walls of the latter are heavier and less delicate than the "cap rock" species. Most of the Stonefort limestone specimens are slightly less ventricose.

In listing previous descriptions of *F. ventricosa* (Meek and Worthen?), it has been customary to include without question the original description of *Fusulina cylindrica* var. *ventricosa* Meek and Hayden, occurring in Kansas and Nebraska, as the original of *Fusulinella ventricosa* (Meek and Worthen?). The description of *Fusulina cylindrica* var. *ventricosa* by Meek and Hayden[8] was not based upon the criteria we now use in differentiating *Fusulina* and *Fusulinella.* Size and exterior form were the bases for their description. It is well known that these criteria do not have generic value in distinguishing *Fusulina* from *Fusulinella;* therefore, we have no way of knowing for certain which species they described. Circumstantial evidence,[9] however, points to the conclusion that *F. cylindrica* var. *ventricosa* Meek and Hayden was a *Fusulina* and is identical with von Staff's *Fusulina secalis* (*secalica*).

[8] Proc. Acad. Nat. Sci., Philadelphia, p. 261, 1858.

[9] Girty, G. H., On the names of American Fusulinas: Jour. Geol., vol. XXII, p. 241-2, 1914. Von Staff, H., Monographie der Fusulinen: Teil III: Paleontographica, Band 59, 1912.

It is most probable that the first description and figures of *Fusulinella ventricosa* were given by Meek and Worthen in their report[10] on the paleontology of Illinois and in Meek's supplementary notes[11] on the fossils he described in that report with Worthen. Meek's supplementary note on the Fusulinae is sufficiently instructive to quote. It refers both to *Fusulina gracilis* and to *"Fusulina ventricosa"* which were figured without description, except for notes on the sources of the specimens in the paleontology report mentioned above.

"Fusulina gracilis and *F. ventricosa;* (figs. 7 and 8, plate XXIV.) —These names were temporarily written on the explanation of this plate, merely with the view of keeping in mind forms with which it was thought desirable that they should be compared in revising the text for the press and not with any intention of ultimately using them as if the fossils were known really to belong to two distinct species. They are, on the contrary, almost certainly extreme varieties of the common *F. cylindrica* Fischer. The first does not agree exactly, in form, with the California specimens for which the name *F. gracilis* was originally proposed, though it does not differ very materially. The other is smaller, and even more ventricose than the Kansas specimens named *ventricosa,* as a mere variety of *F. cylindrica,* and is better entitled to rank as a distinct variety than that figured on the same plate under the name *F. gracilis."*

Occurrence.—Specimens of *F.* aff. *ventricosa* are rare. A few were found at station 370. Others came from stations 251, and 371.

FUSULINELLA n. sp.

Plate 10, figs. 2 and 4

Two specimens of this species were found, but one of them was destroyed during the process of sectioning. Insufficient material prevents a specific description of this form which has several important differences from the species referred to *F.* aff. *ventricosa* above. It is longer, less ventricose, not inflated, and shell walls are less massive.

Occurrence.—The specimen was found at station 337.

FUSULINELLA n. sp.?

Plate 10, fig. 1 *a*

A few specimens of a small *Fusulinella* with strongly folded septa were found which differed from *F.* aff. *ventricosa* above by being dis-

[10] Meek, F. B., and Worthen, A. H., Report, Geol. Surv. Ill., vol. 5, p. 560.

[11] Meek, F. B., Notes on some of the fossils figured in the recently issued Fifth volume of the Illinois State Geographical Reports: Am. Jour. Sci. (ser. 3), vol. VII, p. 484.

tinctly smaller and less inflated. This species bears some resemblance to a Permian fossil, *F. kennoi,* described by Ozawa.

FUSULINELLA EUTHUSEPTA n. sp.[12]

Plates 8, figs. 6-8 *b;* plate 9, figs. 1, 2, 5

Description. The shell is fusiform. The ends are acute. The axis is straight or nearly straight. The average form ratio is 1:3.8, but some are 1:4. The furrows are relatively straight except at the extreme ends. They are bent forward slightly in the equatorial and polar regions, but at the poles they are bent strongly backward. The furrows are shallow.

The initial chamber is minute and is oval in most specimens. The sizes of the initial chambers in five specimens are as follows: 0.032 × 0.048 mm., 0.040 × 0.049 mm., 0.028 × 0.032 mm., 0.033 × 0.052 mm., and 0.030 mm. The buccal aperture is distended. It is about half as high as the chamber and is three or four times wider than high. The floor of the buccal aperture is composed of a basal skeleton and each side of this aperture is bounded by an equatorial ridge which is wide and high at the septa and low between. In this low place between the septa, the ridge is about one-third the height of the chamber. Elsewhere, the basal skeleton is not as thick as the primary shell substance of the spiral wall. The supplementary deposition is about as thick as the primary shell structure and covers both sides and the ceiling of each chamber, except most of the chambers in the last whorl. The primary shell structure has about the same thickness throughout.

Meshwork is obsolete. The septa are nearly plane, but certain sections have been found to show a slight degree of folding in the median region. Some folding exists at the polar zones. The septa are not porous. All of the septa have nearly an equal pitch forward which is within 10° of the radial vector. The number of whorls varies from 8 to 10½. The volutions in the neanic stage are nearly symmetrical.

[12] Gr. euthus — straight, direct (whether horizontal or vertical) ⊥ septa; therefore, straight or non-folded septa.

Statistics of Cross Section

No. whorls	Specimen No. 1 Radial Vector in mm.	Specimen No. 1 Cumulative No. chambers	Specimen No. 2 Radial Vector in mm.	Specimen No. 2 Cumulative No. chambers
Initial Chamber			(.048 Diam.)	
1	.065	12(?)	.040	10
2	.115	30(?)	.059	21
3	.179	48	.093	35
4	.227	72	.131	54
5	.292	95	.163	74
6	.374	123	.220	94
7	.471	154	.284	120
8	.581	185	.366	145
9	.690	214(?)	.488	171
10	(9¾ whorls)	233(?)	.589	201
			(10½ whorls)	

Statistics of Axial Section

No. whorls	Axial Length in mm.	Diameter in mm.	Form Ratio
Initial Chamber		.044	
1	.162	.081	1:2
2	.260	.130	1:2
3	.510	.187	1:2.7
4	.890	.260	1:3.4
5	1.340	.350	1:3.8
6	2.025	.455	1:4.4
7	2.781	.600	1:4.6
8	3.294	.805	1:4.1
9	4.020	.990	1:4
10		(9½ whorls)	

Remarks.—This form is easily distinguished from *F.* aff. *ventricosa* (Meek and Worthen?) by its straight, almost non-folded septa.

Occurrence.—*F. euthusepta* is more common than both of the other Fusulinellas. It was found at stations 250, 251, 370, and 371.

FUSULINELLA MINUTA n. sp.

Plate 8, figs. 2-5

Description.—Subcylindrical to fusiform. Very minute. Ends are truncated or blunt. The axis is straight. Form ratio 1:3.3 to 1:3.7. The furrows are shallow and strongly bent in the polar regions.

The initial chamber is minute and more or less oval. The sizes of

several initial chambers range as follows: .056 × .095 mm., .028 × .048 mm., .040 × .057 mm., and .043 × .044 mm. The walls of the initial chambers are .007—.009 mm. thick. The buccal aperture is about 2½ times wider than high. The two equatorial ridges of basal skeleton which bound the buccal aperture are very low and in places are almost flush with the rest of the basal skeleton away from the channel of the buccal aperture; so, between the septa, the channel of the buccal aperture appears like a canal lying in the basal skeleton without levees on either side. The basal skeleton is thick and extends to the poles. The axial zone is partly filled with supplementary deposition excepting the last whorl and the neanic portion. The basal skeleton is nearly as thick as the spiral wall plus the supplementary deposition. The volume of space for sarcode is nearly equal to the volume of shell substance.

Meshwork is absent. The corresponding transparent layer is thick. The outer dark layer and the transparent layer together are about .012 mm. thick in the last whorl and about .006 mm in the first. The spiral wall increases in thickness gradually. The pitch of the septa is radial. The septa are not folded, and are not porous. The number of whorls ranges from 5 to 6. The whorls in the neanic stage are symmetrical.

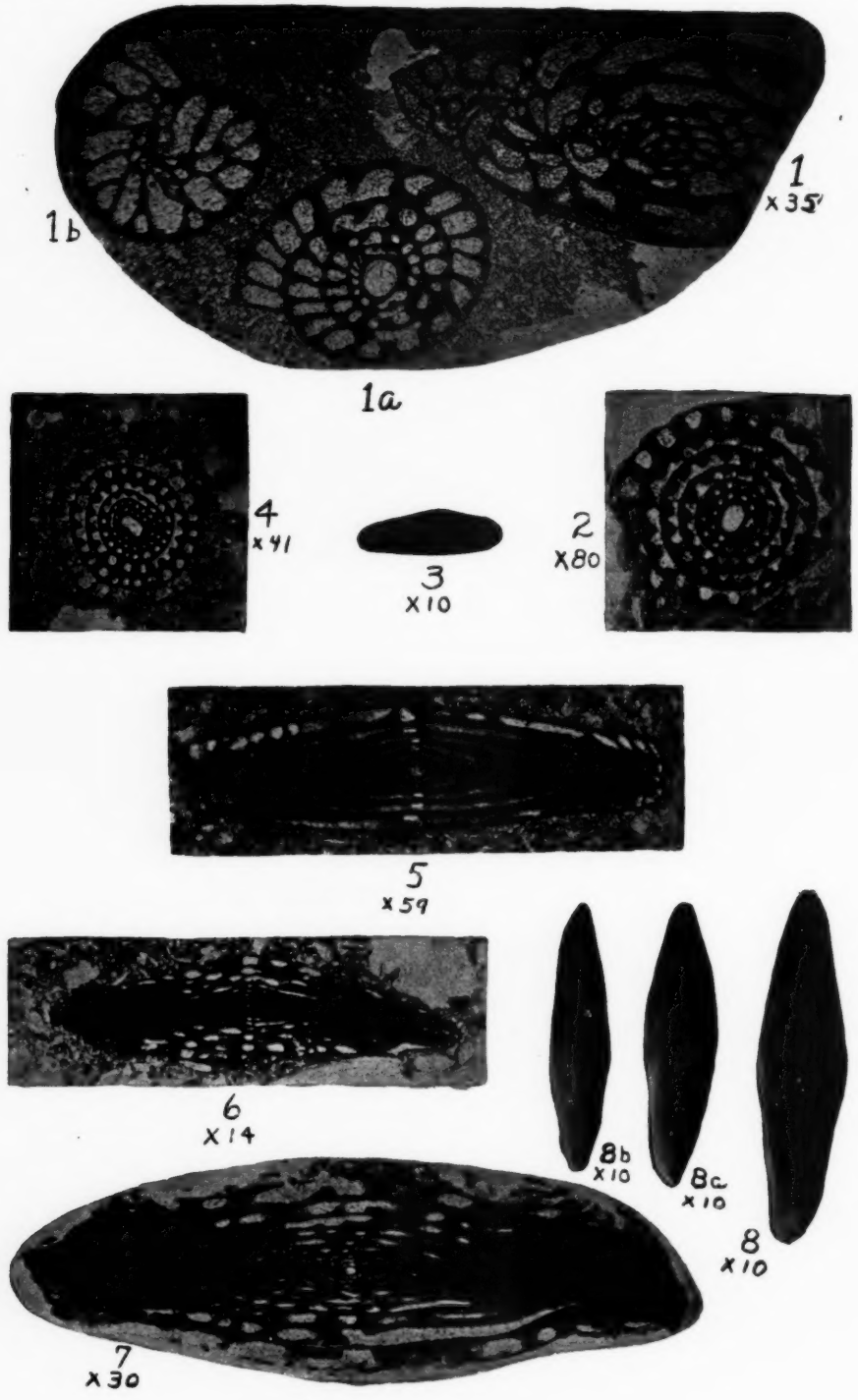
Statistics of Cross Section

No. whorls	Specimen No. 1 Radial Vector in mm.	Specimen No. 1 Cumulative No. Chambers	Specimen No. 2* Radial Vector in mm.	Specimen No. 2* Cumulative No. Chambers
Initial Chamber	.033		.065	
1	.052	10	.097	14
2	.077	23	.130	30
3	.104	39	.170	47
4	.134	58	.228	65
5	.170	77	.285	86½
6	.213	95	.341	108
			(Exactly 6 whorls)	

*Megalospheric (?)

Remarks.—*Fusulinella minuta* is distinguished from *F. euthusepta* by its small size, fewer volutions, relatively large size of the initial chamber, the low equatorial levees of the basal skeleton, and the relatively greater massiveness of the basal skeleton.

Occurrence.—*F. minuta* is less common than *F. euthusepta.* The specimens are from stations 250, 251, 370, and 371.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1
x 35
1a
4
x 41
3
x 10
2
x 80
5
x 59
6
x 14
8b
x 10
8c
x 10
8
x 10
7
x 30

FUSULINELLA (GIRTYINA) VENTRICOSA (Meek and Worthen?)

Plate 9, figs. 3, 4, 6, 6 *a*

Four thin sections of *F. ventricosa* (Meek and Worthen?) from the cap rock of No. 6 coal are included here for comparison with the specimens from the Stonefort limestone. The best description of this form may be found in von Staff's and Schellwien's monograph.[13]

These specimens are from station 377, 9/5/26, Ledford, Saline County, Illinois.

COLLECTING LOCALITIES

Station 237. Stonefort Limestone.
Saline County. Along old road. Elevation about 380. Center N. ½ NW. ¼ sec. 22, T. 10 S., R. 6 N. 7/30/25, L. G. Henbest.

Station 250. Stonefort Limestone.
Saline County. In north hillside ravine. Elevation about 440. Near Center S. ½, NW. ¼ NW. ¼ sec. 29, T. 10 S., R. 6 E. 8/?/25, L. G. Henbest; and 1926, J. M. Weller and L. G. Henbest.

[13] Monographie der Fusulinen: Paleontographica, Teil III, Band 59, 1912.

EXPLANATION OF PLATE 8

FIGS. 1–1 *b*.—*Fusulina prisca*.
1.—Axial section, slightly oblique.
1 *a*.—Cross section.
1 *b*.—Excentric cross section.
These figures show the essential characteristics of the genus *Fusulina*. The meshwork structure in the spiral walls and the absence of widespread basal skeleton and supplementary deposition layers are noteworthy.
Oread limestone, Locompton, Kansas. Station 195.

2–5.—*Fusulinella minuta* n. sp.
2.—Cross section, station 370.
3.—Exterior view, station 250 or 370.
4.—Cross section, station 370. This section is peculiar for its large, subrectangular initial chamber as it appears in cross section.
5.—Axial section, station 250.
Stonefort limestone.

6–8 *b*.—*Fusulinella euthusepta* n. sp.
6.—Axial section, station 370.
7.—Axial section, station 370.
8–8 *b*.—Exterior views, station 370.
Stonefort limestone.

Station 251. Stonefort Limestone—Upper and Lower.
Saline County. First Illinois Central Railroad cut north of Highway No. 1 and northeast of Stonefort. Near SW. corner sec. 20, T. 10 S., R. 5 E. 1925, L. G. Henbest; and 9/3/26, J. M. Weller, G. H. Cady, and L. G. Henbest.

Station 370. Stonefort Limestone.
Williamson County. Hillside ravine, elevation about 540. NE. ¼ SE. ¼ SE. ¼ sec. 34, T. 10 S., R. 4 E. 9/3/26, G. H. Cady, J. M. Weller, L. G. Henbest, and T. A. Hendricks.

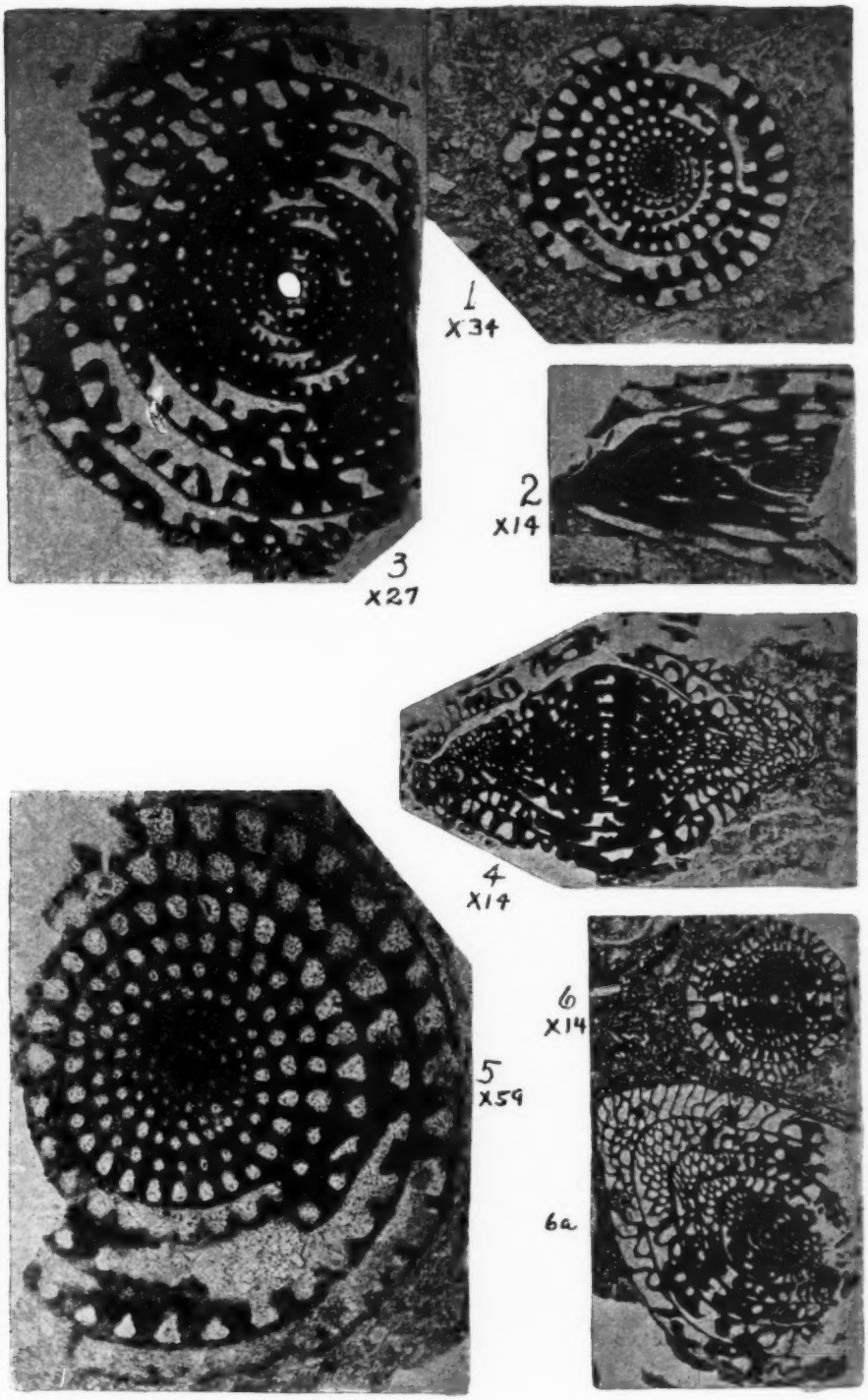
Station 371. Stonefort Limestone—Upper and Lower.
Williamson County. In ravines east of road above coal mine. Elevation about 500. Near Center NE. ¼ SE. ¼ sec. 25, T. 10 S., R. 4 E. 9/3/26, G. H. Cady, L. G. Henbest, J. M. Weller, and T. A. Hendricks.

Station 377. Cap rock of No. 6 Coal.
Saline County. Cut of the electric railroad at Ledford. Near Center W. ½ sec. 31, T. 9 S., R. 6 E. 9/5/26, L. G. Henbest.

EXPLANATION OF PLATE 9

FIGS. 1, 2, 5.—*Fusulinella euthusepta* n. sp.
1.—Cross section, station 250.
2.—Portion of axial section, station 370.
5.—Cross section slightly excentric, station 250.
Stonefort limestone.
3, 4, 6, 6 *a*.—*Fusulinella ventricosa* (Meek and Worthen?)
3[1].—Cross section.
4.—Axial section.
6.—Cross section, immature individual?
6 *a*.—Axial section, slightly oblique.
Cap rock, No. 6 coal, station 377.

[1] The vertical lines fringing the spiral walls in places do not appear in the specimen. They are caused somehow by the photographic process.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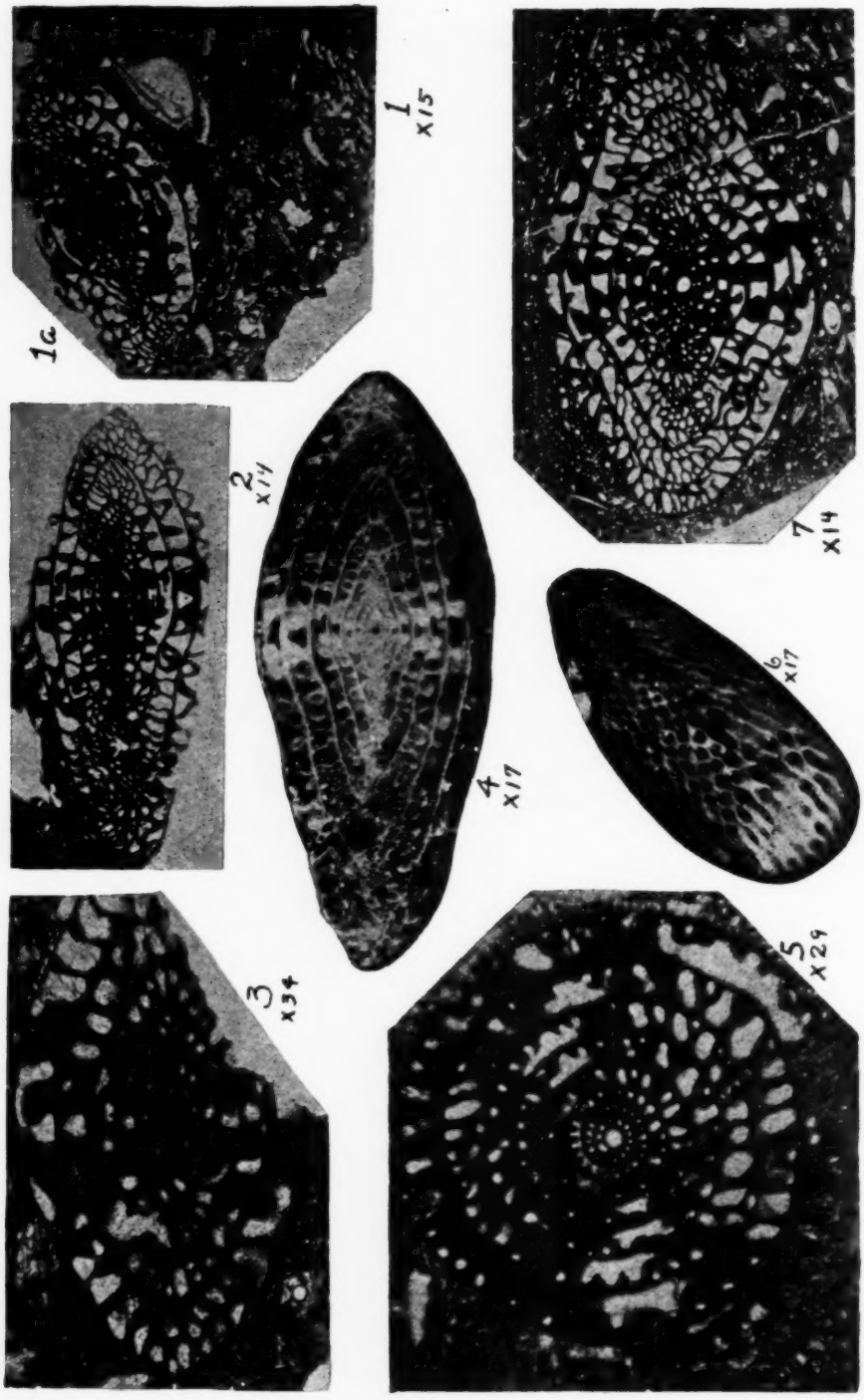
1
x15
1a
7
x14
2
x14
4
x17
6
x17
3
x34
5
x29

EXPLANATION OF PLATE 10

FIG. 1.—*Tetrataxis* sp.
Stonefort limestone member, station 250.

2 and 4.—*Fusulinella* n. sp.
Axial sections of the specimen. Fig. 4 is a photograph made after one-half had been ground away. Fig. 2 is a photograph made after the specimen was ground to thinness. Station 337. Stonefort limestone.

1 *a* and 3.—*Fusulinella* n. sp.?
1 *a*.—Axial section, station 250.
3.—Axial section, slightly excentric, station 250.
Stonefort limestone.

1–7.—*Fusulinella* cf. *ventricosa*.
5.—Cross section, station 371.
7.—Axial section, station 371.
6.—External view of a portion of a shell with the spiral wall removed to show the folding of the septa. Station 371.
Stonefort limestone.